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No. 24: THE COREGONINE FISHES OF NORTHWESTERN
CANADA. BY J. R. DYMOND.

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THE COREGONINE FISHES OF NORTHWESTERN CANADA

By J. R. DYMOND

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INTRODUCTION

The latest check list of North American fishes (Jordan, Evermann and Clark, 1930) lists 12 members of the whitefish family (Coregonidae) as occurring in the northwest, only one of which, *Prosopium quadrilaterale*, extends to the Great Lakes. In contrast to this, most of the other freshwater fishes of the area are regarded as belonging to species common in the Great Lakes region. Species common to the two areas include:

(1) *Cristivomer namaycush*, (2) *Catostomus catostomus*, (3) *Catostomus commersonii*, (4) *Moxostoma aureolum (lesueurii)*, (5) *Esox lucius*, (6) *Stizostedion vitreum*, (7) *Cottus cognatus*, (8) *Pungitius pungitius*, (9) *Lota maculosa*.

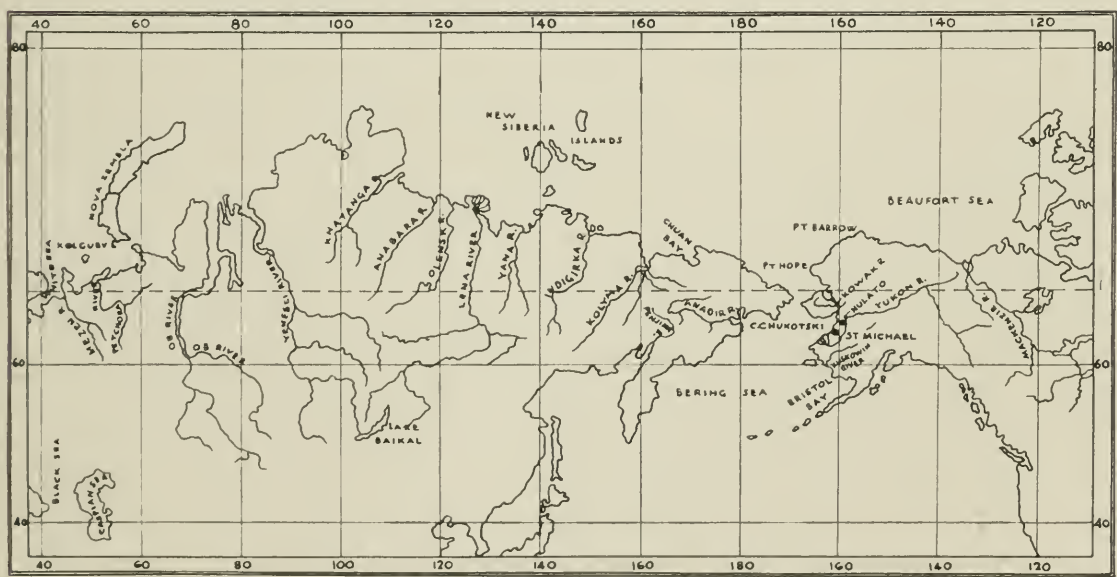
Similarly none of the northwest American and Siberian coregonines was considered as belonging to the same species, although at least three of the species listed above (*C. catostomus*, *Esox lucius*, *P. pungitius*) are known to extend across Canada and into Siberia and our *Lota* has since been regarded as of the same species as that of Europe and Asia.

It has long been doubted whether the coregonine fauna of north-western America is actually as distinct as the 1930 check list would suggest. Two factors have, however, combined to retard an understanding of this fauna. The first of these is that, until recently, few specimens have been available for study; the second is the difficulty of understanding relationships within the group.

A history of the early explorations which contributed to our knowledge of the natural history of the Northwest Territories has been published by Preble (1908). Although fish were forced on the attention of every explorer and trader since they were a mainstay of the food supply of the early trading posts, most of the early explorers (Hearne, 1795; Mackenzie, 1801) merely record the presence of such fish as whitefish, inconnu, grayling, trout, pike, pike-perch, suckers and burbot. Hearne is credited with being the first to record the inconnu,—by description, not by name. The name, poisson inconnu, is first mentioned by Mackenzie. Richardson (1823, 1836), naturalist of Sir John Franklin's first and second expeditions, was the first who took any scientific interest in the fishes of the region. It was he who named and described *Prosopium quadrilaterale* (1823), *Leucichthys lucidus* (1836), *L. tullibee* (1836) and *Stenodus mackenzii* (1823) of the group considered in the present paper. Unfortunately, specimens collected during the first expedition had to be abandoned during the disastrous overland journey from the Arctic to Fort Enterprise. The Fauna Boreali-Americana which embodied the natural history results of Franklin's two expeditions



Map of Northwestern Canada showing location of places mentioned in the text.



Map of Northern Asia showing location of places mentioned in the text.

was for long the chief source of information on the natural history not only of the Northwest Territories but also of northern North America. It is still an invaluable source of information on northern animal life.

Robert Kennicott, beginning in 1859, spent between three and four years collecting in the Yukon and Mackenzie River region but according to Preble (1908) a considerable part of his collection was lost on the Methye Portage "probably having been thrown away by some weary and irresponsible voyageur". Of Preble's own collections of fish, he says "By some unfortunate accident, a considerable portion of the collection disappeared in the interval between its arrival in Washington and the time it could be examined. These lost specimens unfortunately included most of the examples of *Coregonus*—specimens which would have settled a number of doubtful points."

Occasional specimens collected by explorers, travellers, etc. are all that have hitherto been available for study. A history of the studies contributing to our knowledge is included in the discussion of the individual species.

The difficulty of coregonine systematics is due largely to the extent to which members of the group vary under different ecological conditions. Body form and other morphological characters vary from one body of water to another. Indeed Hart (1931) showed that *Coregonus* from different parts of the same lake (Lake Ontario) differed in their body proportions. Dymond and Hart (1927) found that *Coregonus* of Lake Abitibi differed from the same species of Lake Nipigon in the same respects as *Leucichthys nipigon* of Lake Abitibi differed from the same species of Lake Nipigon, suggesting that for each body of water there is a particular form to which different coregonines are moulded.

In the case of many, perhaps all species of fish, body proportions and some other characters change with growth. Hart (1931) found that for *Coregonus clupeaformis* the more prominent changes with growth are increases in relative body depth, interorbital width and length of fins on the ventral part of the body and the decreased proportionate size of the head and its parts, particularly the eye. Since whitefish in some bodies of water do not attain nearly as large a size as they do in others, direct comparison is apt to be misleading unless one has specimens of the same size. When one is dependent on commercial fishermen, trappers, etc., as has occurred in the case of Northwest Territories' coregonines, it is usually not possible to obtain specimens that are directly comparable.

Fortunately, there is little sexual dimorphism among the coregonines, although the subject has not yet been thoroughly explored. Hart (1931) found for *Coregonus clupeaformis* that males have larger fins in proportion to their size than females. He also obtained some evidence that males

may also have a longer snout and a less deep body. Until the matter can be more fully investigated, there must be some doubt as to whether specimens of the same size are directly comparable unless they are of the same age and of the same stage of sexual development.

The sort of differences that complicate the comparison of specimens of different sex and size especially if they have developed under conditions that affect rate of growth are illustrated by a consideration of the Kamloops trout. Mottley (1936) has shown that in this species the head increases in length at a slower rate than the body in the case of smaller trout and at a faster rate in the larger specimens. The change from negative to positive heterogony (Huxley, 1932) occurs at the onset of sexual maturity. Males show a greater positive heterogony throughout the large-size groups. Since trout do not all mature at the same age or the same size, there is much variability in the size at which positive heterogony begins. The snout increases in length at the same rate as the body in the case of small males but more slowly in small females; in larger fish both males and females show positive heterogony but it is more strongly marked in males than in females. The positive heterogony of the snout length and also of the head length of the larger fish is due mainly to the relative rate of growth of the pre-ocular region. The length of the maxillary process corresponds closely to the length of the snout in its growth characteristics. The eye increases in size at a rate less than that of the body in both small and large trout but the negative tendency is greater in females than in males. In smaller trout the body undergoes extension in length at a faster rate than extension in depth or width but in larger fish this trend is reversed and positive heterogony sets in. Caudal peduncle length is relatively greater in small fish than in larger ones. Similar changes, though often less marked, characterize the growth rate of other characters such as interorbital width, caudal peduncle length and depth and fin lengths.

Body proportions are not affected to the same extent by growth and sex in the coregonines as they are in salmonid fishes. Nevertheless, Hile (1936) showed that permanent morphological differences exist between different year classes of the same population of *Leucichthys artedi* and Koelz (1927) discussing whitefish reared in the New York Aquarium from eggs of Lake Erie parents reports that "the body parts show great modifications in all the specimens and none of them closely resemble any whitefish taken in the Great Lakes. The most striking differences are changes in the shape of head parts. The head throughout is much deeper than in normal whitefish and its dorsal contour usually is decurved conspicuously anterior to the orbit. The premaxillaries are often vertical in position, which is not known to be the case in normally

reared individuals. The head is broader, especially across the snout, and the adipose is much larger usually". After comparing measurements of various characters, he concludes "It is clear that the artificially reared specimens have a proportionately longer head, eye, maxillary, snout and paired fins and fewer gill-rakers than naturally reared fishes—aquarium conditions thus have produced or permitted the development of individuals that are strikingly different from those that are found in nature. Even characters that are considered generic, such as the position of the premaxillaries, have been altered."

The number of gill-rakers is usually one of the least variable of the characters used to distinguish species but Thienemann (1912), Surbeck (1921) and Kreitmann (1929) as quoted by Hile (1936) have all shown that the number of gill-rakers was changed in various species of coregonines following their introduction into new habitats.

The difficulties of coregonine systematics are therefore due to extensive modifications produced by the direct action of the environment superimposed on whatever genetic differences characterize the different populations.

SPECIMENS AVAILABLE FOR STUDY

Following is a list of the specimens which I have had available for study in the collections of the Royal Ontario Museum of Zoology. The names of the persons to whom the Museum is indebted for procuring the specimens are indicated in the case of each collection. The collection, preservation and shipment of these specimens has often involved considerable time and trouble. Our thanks are extended to each for his contribution to the present study; without their co-operation this work could not have been undertaken.

Locality	Number of specimens	Collector
<i>Coregonus</i>		
Kittigasuit.....	11	K. H. Lang
Peel River.....	18	K. H. Lang
Squanga Lake, Yukon Territory....	6	Alfred Dickson
Yukon River near Dawson.....	3	James Hughes
Arctic Red River.....	5	R. W. Dodman
Baker Lake and vicinity.....	8	C. H. D. Clarke
<i>Prosopium</i>		
Yukon River at Dawson.....	5	James Hughes
Baker Lake and vicinity.....	6	C. H. D. Clarke
Great Bear Lake.....	1	M. Meikle
	3	Hudson's Bay Co.
Clinton Colden Lake.....	1	C. H. D. Clarke
Rutledge River (tributary to Great Slave Lake via Taltson River)....	3	Frank Conibear
Lesser Slave Lake.....	1	T. F. Blefgen
	5	R. B. Miller

Locality	Number of specimens	Collector
<i>Leucichthys</i>		
Kittigasuit.....	2	K. H. Lang
Kidluit.....	9	K. H. Lang
Tuktuyaktok (Port Brabant).....	2	K. H. Lang
Aklavik (Whitefish station).....	16	K. H. Lang
Peel River.....	1	K. H. Lang
Yukon River near Dawson.....	1	Jas. Hughes
Arctic Red River.....	6	R. W. Dodman, Hudson's Bay Co.
Baker Lake and vicinity.....	5	C. H. D. Clarke
Great Bear Lake.....	2	M. Meikle
	2	G. E. Duncan
	4	Hudson's Bay Co.
	4	G. A. LaBine
<i>Stenodus</i>		
Peel River.....	2	K. H. Lang
Yukon River near Dawson.....	1	James Hughes
Arctic Red River.....	1	R. W. Dodman
Fort McPherson.....	2	John Patterson
Slave River at Fort Smith.....	12	Frank Conibear
	1	George Whitely
<i>Coregonus</i> x <i>Stenodus</i> hybrid		
Kidluit.....	4	K. H. Lang

In addition to our own collections, I examined the following material in the United States National Museum. For this privilege, I am indebted to Dr. Leonard P. Schultz, Curator of Fishes, to whom my thanks are extended.

<i>Coregonus kennicotti</i>	Type. no.	8971	Fort Good Hope, N.W.T.
"	"	29904	St. Michaels, Alaska
<i>nelsonii</i>	"	38935	Kowak River, Alaska
"	"	38926	" " "
"	"	29898	Nulato, Alaska
"	"	29900	" "
<i>Prosopium oregonium</i>	Type. no.	62987	McKenzie River, Ore.
<i>Leucichthys pusillus</i>	" "	38366	Kowak River, Alaska
<i>Leucichthys laurettae</i>	" "	27695	Pt. Barrow, Alaska
(4 specimens)			

In the British Museum (Natural History) I had an opportunity to examine a specimen of the Asiatic *Coregonus nasus* from the lower Ob River. For this privilege I owe my thanks to Mr. J. R. Norman, Assistant Keeper, Department of Zoology.

In the National Museum of Canada, where the types of the species of *Leucichthys* from northwestern Canada described by Harper and

Nichols (1919) are stored, I was accorded the privilege of examining them by Dr. R. M. Anderson, Chief of the Division of Biology.

A specimen of *Coregonus* from Beauvert Lake, Alberta, was kindly loaned me for examination by Dr. D. S. Rawson, Department of Biology, University of Saskatchewan.

The collections of the Royal Ontario Museum of Zoology contain large series of specimens of *Coregonus*, *Prosopium* and *Leucichthys* from the Great Lakes, Hudson and James Bays and the Prairie Provinces, which have been available for purposes of comparison.

METHODS OF MAKING MEASUREMENTS AND COUNTS

For ready comparison of size of body parts, actual measurements of head length, head depth, eye, snout, body depth and width, fin lengths, etc., have been divided by standard length and the resulting proportions expressed as thousandths of the standard body length. Thus an actual head length of 79 mm., in the case of a fish 393 mm. long to end of vertebral column, is represented as head length 201.

In most cases measurements were made as described by Koelz (1929).

Standard length was measured from the junction of the premaxillaries to the end of the last vertebra.

Total length was measured to the end of the middle ray of the caudal fin and is expressed in inches, unless otherwise stated.

Interorbital is the least distance as measured by dividers across the bony part of the skull between the orbits.

Caudal peduncle length is the distance in a straight line from a point on the lateral line vertically above the posterior insertion of the last ray of the anal fin to the end of the last vertebra.

Caudal peduncle depth is the least depth of the caudal peduncle.

Dorsal and anal fin lengths are the lengths of the longest rays.

Pectoral and ventral fin lengths were measured from the anterior edge of the structural base of the fins to the tip of the longest ray.

All of the unbranched rays at the front of the fins, no matter how short, were counted. These have been added to the number of branched rays and the total number indicated as the number of fin rays. The last ray of the dorsal and anal fins was counted as one, even though divided to the base and appearing as two separate rays.

Adipose length is the distance as measured by dividers from the anterior insertion of the fin to its farthest tip.

Lateral line scales were counted only to the end of the vertebral column.

Gill-rakers were counted as described by Koelz, every visible raker being included in the count.

NOMENCLATURE

There has been some variation in the spelling of a number of the specific names of the species discussed in the present paper. In quotations, direct or indirect, the spelling of the author concerned has been retained; elsewhere the spelling of the original description or the one now in general use has been adopted. Thus *clupeiformis* will be found in quotations from earlier authors, whereas *clupeaformis* is the spelling used elsewhere in the paper.

COREGONUS

Apparently the first scientific name by which the whitefish of Canada was known was *lavaretus*, the name under which Pennant (1785) referred to the whitefish of Hudson Bay.

Richardson (1823, 1836) considered the whitefish of northwestern Canada, of which he must have seen many thousands, as identical with that of the Great Lakes, for he describes it under LeSueur's (1818) name *albus*, the specific name then used for the Great Lakes *Coregonus*.

In 1866, Günther introduced the name *richardsonii* for the whitefish of Arctic America, which he said was "very closely allied to *C. albus*, from which it differs in the form of the maxillary". He described the maxillary as extending "to the anterior edge of the eye, and its length is one-fourth that of the head. The supplementary bone of the maxillary is short, broad, semicircular". He gave the lateral line scales as (72-) 77-80 but failed to give the number of gill-rakers. Nor did he give the locality from which any of the specimens on which his description was based were obtained. His specimens of *richardsonii* he listed as:

- a. Nineteen inches long: stuffed. Presented by J. Rae, Esq.
- b-c. Nineteen inches long: stuffed. From the collection of the Zoological Society.

He also said "I have seen another example from the Museum at Haslar Hospital, also stuffed, and 22 inches long, presented by Sir J. Richardson to the latter institution, but without indication of locality."

As northwestern Canada and Alaska have a similar fish fauna, the history of the nomenclature of Alaskan whitefishes is of interest in the present connection.

Dall (1870, 1871) refers to the true whitefishes (*Coregonus*) of Alaska under the names broad whitefish (*Coregonus muksun*) and humpback (*Coregonus* sp. indet.). However, Jordan and Copeland's (1877) check list of the fresh-water fishes of North America does not include any reference to northwestern *Coregonus*. Bean (1882 c) included the true whitefishes of Alaskan and adjacent waters under the name *clupeiformis* and gave its range as the Great Lakes region to the Polar Sea, including

Alaskan localities. In Jordan and Gilbert's Synopsis (1883) two species are recognized, *kennicotti* and *clupeiformis*. The latter was regarded as the whitefish of the "Great Lakes and northward". By "northward" they intended to include the Arctic coast of the Northwest Territories since they include *richardsonii* among the synonyms of *clupeiformis*. The name *kennicotti* was given by Milner (1883) in Jordan and Gilbert's Synopsis to the form designated by Dall and later by Bean (1884, 1890) as broad whitefish. This, he said, was "a strongly marked species, well distinguished among the American forms by the very obtuse head, but perhaps identical with some Siberian species". His description mentioned "back not greatly elevated. Head very short and deep . . . maxillary extremely short and broad, not quite reaching to the eye . . . its supplemental bone broad ovate, broader than *clupeiformis*. Gill-rakers as in *C. quadrilateralis*" but he did not specify either the number or length of gill-rakers. "Types Nos. 8971 and 9600 of the United States National Museum from Fort Good Hope, British America, and Yucon River, Alaska, respectively".

In 1885 Bean gave the name *nelsonii* to the form known as the humpback whitefish in the northwest. In his original description he says it may readily be distinguished from *clupeiformis* by its greatly arched and much compressed back.

Bean in several papers (1884, 1885b, 1888, 1890, 1894) regarded the whitefishes of the northwest as belonging to two species, one he consistently called *nelsonii*, the name he had proposed for the humpback whitefish, the other he sometimes called *richardsonii* and sometimes *kennicotti*. For instance, in 1890 he wrote "the largest one (*Coregonus richardsonii*) sometimes reaching a weight of thirty pounds. For many years this was believed to be identical with the common whitefish of our Great Lakes fisheries, but it differs from this in many particulars. This species was known to the Russians as the "muksun" This is the species which Milner named *Coregonus kennicotti*". With reference to the relationship between the whitefishes of the Great Lakes and those of the northwest Bean in 1888 stated that *clupeiformis* "the common whitefish of the Great Lakes" did not extend "very far into British America and is replaced northwestward in Alaska and the Arctic portion of British America by *Coregonus richardsoni* (*kennicotti* of late works)".

Jordan and Evermann's (1896) check list included the following northwestern whitefishes:

Coregonus kennicotti—Broad whitefish; muksun of the Russians.

Mackenzie and Yukon Rivers.

Coregonus richardsonii—Arctic North America.

Coregonus nelsonii—Humpback whitefish. Alaska from Bristol Bay northward.

It is stated positively that *clupeiformis* is "not in Alaska nor Arctic America". Evermann and Smith (1896) listed the same three species from northwestern localities. Evermann and Goldsborough (1907a) in their Fishes of Alaska listed only *kennicotti* and *nelsonii*.

The 1911 Review by Jordan and Evermann dropped *richardsonii* without listing it in the synonymy of any other species and regarded the northwestern whitefishes as belonging to *nelsoni* and *kennicotti*. The 1930 check list of Jordan, Evermann and Clark continued to regard the northwestern whitefishes as belonging to the same two species, *nelsonii* and *kennicotti*. *C. richardsonii* was listed questionably in the synonymy of *clupeaformis*, the whitefish of the "Great Lakes, excepting Lake Erie; and neighboring waters", a rather illogical procedure.

As a result of Bean's statement about the gill-rakers of *kennicotti*, this species has long continued to be erroneously considered as allied to *quadrilateralis*. Jordan and Evermann in their 1896 and 1911 publications list *kennicotti* under subgenus *Prosopium*. In 1896 *richardsonii* was also so listed, but by 1911 *richardsonii* had been dropped. The 1930 check list included *kennicotti* under *Prosopium* which had now been raised to generic rank.

Gilbert (1895) reporting on a specimen from the Delta of the Mackenzie River identified as *kennicotti* said: "This species is in many respects midway between *Prosopium* and *Coregonus*. The gill-rakers are short and few in number, but are slender. The preorbital is very long and narrow and the supplemental bone broad and ovate. Thus the gill-rakers are about as in *quadrilateralis* and other species of the section *Prosopium*, while all the other characters given ally the species with *clupeiformis* and the rest of the *Coregonus* group."

Evermann and Goldsborough's (1907a) Fishes of Alaska said that it (*kennicotti*) may be readily distinguished from the round whitefish found in the same waters by the somewhat larger mouth, longer and more numerous gill-rakers, large and much more caducous scales, and more elevated back."

There is a good deal of variation in the length of gill-rakers of northwestern whitefish. This is well shown by 2 specimens from Kittigasuit, one of which, 367 mm. in standard length, had gill-rakers 8 mm. in length, while the other, 378 mm. long, had gill-rakers only 4 mm. long. These are respectively 2.18 and 1.06 per cent of the standard lengths of the fish. Similar differences are shown by the gill-raker lengths of a series of specimens from the same locality. Unfortunately, these specimens are represented by skins only, so that the lengths could not be determined as accurately as in the case of whole specimens. However, the wide range in gill-raker length should be obvious from the following list.

Estimated standard length	Gill-raker length	Estimated standard length	Gill-raker length
494	6	415	6
481	7	410	7½
454	5	400	8½
444	10	383	5
421	12		

The same difference is not apparent in the case of specimens from Baker Lake nor from Arctic Red River as shown by the following measurements:

Standard length	Gill-raker length	Standard length	Gill-raker length
Baker Lake		Arctic Red River	
455	8	426	8½
427	6½	417	9
423	7	393	7
422	7½	374	7
417	7	370	7
408	7		
403	7½		
337	6½		

For comparison, the gill-raker lengths of Lake Ontario and Lake Nipigon whitefish are presented below.

Standard length	Gill-raker length	Standard length	Gill-raker length
Lake Ontario		Lake Nipigon	
435	8	363	7
420	8	353	7 1/3
417	9	349	7
392	8	344	6
388	6	342	5½
356	7	341	6
342	8	340	6
338	7	334	6
333	7	328	7
327	7		

When I examined the type specimen of *kennicotti* in the United States National Museum, I recorded its gill-rakers as being between 5 and 6 mm. in length and the standard length as 477 mm.

Thus the reduced gill-raker length that has long been regarded as characteristic of northwestern whitefish is not general; it appears to be exceptional rather than general. May it be that the reduced length is in some way related to the brackish water sojourn of some individuals? It will be noticed that individuals with specially short rakers are much

more common among Kittigasuit specimens. North of Kittigasuit the water begins to turn brackish, according to Mr. Lang.

COMPARISON OF NORTHWEST AND GREAT LAKES COREGONUS

There is considerable variation among the whitefish of the genus *Coregonus* in the Northwest Territories. Table 1 presents measurements and counts for collections from a number of localities; where two or more specimens are included in a collection the values given are averages.

Specimens from some localities show considerable divergence from the whitefish of the Great Lakes, while others correspond rather closely to some forms found in these bodies of water. The number of gill-rakers in Great Lakes specimens usually lies between 26 and 29, with an average of slightly more than 27 (Koelz, 1929). Northwest Territory specimens usually have 21 to 26 gill-rakers (extreme range 18 to 27). Those from Kittigasuit and Peel River average about 23, Yukon River about the same, Arctic Red River and Baker Lake 25 or 26, but six specimens from Squanga Lake, near Dawson, Yukon Territory, average 28 with a range of 26 to 30. The type of *kennicotti* has 21. A specimen from St. Michaels, Alaska, labelled *kennicotti* in the United States National Museum has 20 gill-rakers, as had one reported by Gilbert (1895) from the Delta of the Mackenzie River. In his description of *nelsonii* Bean gave the gill-rakers as "about 26". I have not seen the type of *nelsonii* but four specimens from Alaska in the United States National Museum labelled *nelsonii*, two from Nulato, the type locality for the species, and two from Kowak River had gill-rakers respectively 23, 21, 21 and 21. Six specimens from Grantley Harbour and Renideu Station, Port Clarence, identified as *nelsonii* by Scofield (1899) had an average of 20 rakers. Berg gives the range of gill-raker numbers of the Siberian *nasus* as 19 to 25. A single specimen which I examined in the British Museum had 22.

It therefore appears that a number of areas in the Northwest and Yukon Territories and Alaska have whitefish which in gill-raker count are similar to the Siberian *nasus*, while within the same region occur whitefish showing almost perfect gradation in gill-raker number between *nasus* and typical *clupeaformis* of the Great Lakes, for example Kittigasuit, Peel River and Yukon River 22-23, Arctic Red River 25, Baker Lake and Thelon River 25-26, Hudson Bay 26-27, Great Lakes 27-28.

Great Lakes whitefish have an average of 82 or 83 scales with a range of 77 to 88 (extreme range 73 to 94) (Koelz, 1929). Whitefish from Kittigasuit and Squanga Lake have 84 to 86 scales on the average but Peel River, Yukon River and Arctic Red River whitefish have practically the same scale count as Great Lakes specimens, while Baker Lake and Thelon River specimens have a much lower number. The type

TABLE No. 1

PROPORTIONATE MEASUREMENTS AND COUNTS OF BODY PARTS OF *Coregonus* FROM DIFFERENT LOCALITIES

	Kittigasuit	Peel River	Squanga Lake	Yukon River	Arctic Red River	Baker Lake	<i>kennicolti</i>	<i>kennicolti</i>	<i>nelsonii</i>	<i>nasus</i>
	2	17	6	3	5	8	1 (type)*	1 (Alaska)	4	1
Number of specimens.....	373	355	247	356	396	411	477	445	363	333
Standard length.....	85	83	86	82	83	77	90	85	81	90
Scales.....	22	22.8	28	22.3	25	25.8	21	20	22	22
Gill-rakers.....	7.5	8.2	8.4	8	8	8.2	9	8	8.8	8
Branchiostegals.....	148	159	191	169	159	180				
Pyloric caeca.....	208	210	213	205	200	209	189	202	205	199
Head length.....	147	155	144	149	141	143	149	157	143	153
Head depth.....	44	42	53	45	42	40	40	43	45	44
Eye.....	50	54	54	58	54	58	46	52	54	45
Snout.....	64	65	66	65	61	62	62	71	64	63
Interorbital.....	55	56	60	55	58	63	46	51	57	44
Maxillary.....	287	296	243	245	285	241	210	254	254	312
Body depth.....	148	147	125	152	129	148	...	130	109	93
Body width.....										
Caudal peduncle										
Length.....	105	107	106	106	112	120	134	106	112	96
Depth.....	91	101	86	90	92	85	...	99	89	102
Dorsal rays.....	14	13	12	13.3	14.4	12.7	13	14	13.5	12
Dorsal height.....	173	192	172	188	183	172	165	157	156	201
Dorsal base.....	137	141	123	129	137	...	...	...	...	135
Anal rays.....	14.5	13.5	12.5	13.3	14.6	13	15	14	13.5	16
Anal height.....	130	140	118	143	134	122	...	...	...	156
Anal base.....	127	130	117	119	132	...	...	...	...	153
Pectoral length.....	173	196	186	183	172	174	172	181	161	192
Ventral length.....	164	181	173	176	165	167	165	157	146	186
Adipose.....	83	86	...	...	81	78	80	88	85	80

*The type specimen of *kennicolti* is a skin. Because of the impossibility of being certain of the standard length and certain other measurements, such as body depth and width and caudal peduncle length and depth, the measurements indicated must be regarded as merely approximate. For that reason they are not used in the comparisons based on this table.

of *kennicotti* had 90 scales; this is outside the range shown by the eleven Kittigasuit specimens (80 to 88) but within the range of the 17 Peel River specimens (78-93). The other specimen labelled *kennicotti* in the United States National Museum collection had 85 scales. A specimen from the Delta of the Mackenzie River reported as *kennicotti* by Gilbert (1895) had 90 scales on one side and 87 on the other. Two specimens from Barter Island near the mouth of the Mackenzie River identified as *kennicotti* by Scofield (1899) had 86 scales. Five from Grantley Harbour which the same author identified as *nelsonii* had an average of 83 (80-88). The type of *nelsonii* was said to have 88 scales (Bean 1885a). The four Alaska specimens of *nelsonii* in the United States National Museum had 79, 79, 82 and 82 scales respectively. Berg (1936) gives the number of scales in the Siberian *nasus* as 85 to 105. The single specimen of *nasus* which I examined in the British Museum had 90 scales.

In number of scales there is little difference between Northwest Territories and Great Lakes whitefish. The only population examined which shows a divergence is that of Baker Lake and Thelon River which averaged 77 scales, with a range of 70 to 85. It is perhaps significant that specimens (32) from Hudson and James Bay, into which Baker Lake and Thelon River drain, were found to have an average of 77 scales, with a range of 71 to 83. Hudson Bay whitefish had, however, gill-rakers intermediate in number between those of Baker Lake and the Great Lakes.

The difficulty of comparing body proportions of fish of different sizes has already been discussed. In an effort to overcome this difficulty so far as our present knowledge permits, tables 2 and 3 have been constructed. Here fish from various localities are compared with a common standard, namely Lake Nipigon whitefish. For each of the characters,—head, eye, body depth, etc.,—there is given under A the proportionate measurements for specimens from the localities indicated; under B, the proportionate measurements of whitefish of the corresponding length from Lake Nipigon and under C the difference between the proportionate measurements of specimens from the locality indicated and those from Lake Nipigon.

Lake Nipigon whitefish have been chosen as a basis of comparison because for many of the body characters of these fish Hart (1931) has given curves from which may be obtained the proportionate measurements of the part for any given length of specimen. These measurements and sizes are of course average ones. For characters for which Hart does not give curves he gives proportionate measurements (his table V) for a wide variety of sizes of fish. The localities listed in these tables correspond to those listed in table 1 except for Lake Ontario. In order to pro-

vide a basis of comparison with specimens from one of the Great Lakes, the values for Lake Ontario specimens from Pleasant Point are included. These were taken from Hart's results, presented in his table IV.

Table 2 indicates that whitefish from all of the localities represented had relatively shorter heads than those from Lake Nipigon. The shortest headed fishes were those from Arctic Red River (-14) which were of the same relative length as the British Museum specimen of *nasus*. In order of increasing length of head came fish from the following localities, —Lake Ontario (-12), Yukon River and a specimen labelled *kennicotti* from Alaska (-8),* four specimens of *nelsonii* (-7), Kittigasuit and Baker Lake (-5), Squanga Lake (-4), Peel River (-3) and Lake Nipigon (0).

In spite of having shorter heads, fish from three of the localities had larger eyes, *kennicotti* (Alaska) (+4), Squanga Lake (+3) and Kittigasuit (+0.5). Three of the populations have eyes of equal size to those of Lake Nipigon, —Yukon River, Arctic Red River and four specimens of *nelsonii*, while four had smaller eyes, —Peel River (-3), Lake Ontario (-2.5), Baker Lake and *nasus* (-1.5).

While the shorter heads (as compared with those of Lake Nipigon whitefish) of the ten collections represented in table 2 do not have correspondingly small eyes, they do all have shorter snouts. The shortest-headed forms, however, are not usually those having the shortest snouts. *C. nasus* is the shortest snouted form (-15), followed in order by Kittigasuit (-11), *kennicotti* (Alaska) and Arctic Red River (-7), Peel River and *nelsonii* (-6.5), Squanga Lake (-5.5), Lake Ontario (-4), Baker Lake (-3) and Yukon River (-2.5).

In their descriptions of *richardsonii* and *kennicotti*, Günther and Bean stress the length and shape of the maxillary. Günther said that in the whitefish of Arctic America which he named *richardsonii* the maxillary extends to the anterior edge of the eye and that the supplementary bone is short, broad and semicircular. Bean in his description of *kennicotti* said "maxillary extremely short and broad, not quite reaching to the eye . . . its supplemental bone broad, ovate, broader than *clupeiiformis*".

There is very little difference between northwestern and Great Lakes whitefish in the matter of the backward extension of the maxillary relative to the eye. In some northwestern specimens the maxillary does not quite reach a vertical through front of eye, whereas in many Great Lakes specimens it projects slightly beyond such a vertical. It is, how-

*Measurements for the type specimen of *kennicotti* are not included in these comparisons since the type is a skin, the measurements for which are not dependable because of the impossibility of being certain of the standard length.

TABLE No. 2
PROPORTIONATE MEASUREMENTS OF BODY PARTS OF *Coregonus* FROM DIFFERENT LOCALITIES (A), COMPARED WITH SIMILAR MEASUREMENTS OF LAKE NIPIGON FISH OF COMPARABLE SIZE (B). (C) IS THE DIFFERENCE

Locality	Length			Head			Eye			Snout		
	A	B	C	A	B	C	A	B	C	A	B	C
Kittigasuit.....	373	208	213	- 5	213	213	44	43.5	+0.5	50	61	-11
Peel River.....	355	210	213	- 3	213	213	42	45	-3	54	60.5	-6.5
Squanga Lake.....	247	213	217	- 4	217	217	53	50	+3	54	59.5	-5.5
Yukon River.....	356	205	213	- 8	213	213	45	45	+0	58	60.5	-2.5
Arctic Red River.....	396	200	214	-14	214	214	42	42	+0	54	61	-7
Baker Lake.....	411	209	214	-5	214	214	40	41.5	-1.5	58	61	-3
<i>kennicolti</i> (Alaska).....	445	202	210	-8	210	210	43	39	+4	52	59	-7
<i>nelsonii</i>	363	205	213	-7	213	213	45	45	0	54	60.5	-6.5
<i>nasus</i>	333	199	213	-14	213	213	44	45.5	-1.5	45	60	-15
Lake Ontario.....	410	202	214	-12	214	214	39	41.5	-2.5	57	61	-4

TABLE No. 3
PROPORTIONATE MEASUREMENTS OF BODY PARTS OF *Coregonus* FROM DIFFERENT LOCALITIES (A), COMPARED WITH SIMILAR MEASUREMENTS OF LAKE NIPIGON FISH OF COMPARABLE SIZE (B). (C) IS THE DIFFERENCE

Locality	Length			Body depth			Caudal peduncle length			Height dorsal fin		
	A	B	C	A	B	C	A	B	C	A	B	C
Kittigasuit.....	373	287	278	+9	278	278	105	118	-13	173	176	-3
Peel River.....	355	296	272	+24	272	272	107	119	-12	192	177	+15
Squanga.....	247	243	245	-2	245	245	106	117	-11	172	183	-11
Yukon River.....	356	245	272	-27	272	272	106	119	-13	188	177	+11
Arctic Red River.....	396	285	285	0	285	285	112	118	-6	183	174	+9
Baker Lake.....	411	241	287	-36	287	287	120	122	-2	172	172	0
<i>kennicolti</i> (Alaska).....	445	254	300	-46	300	300	106	127	-21	157	168	-9
<i>nelsonii</i>	363	254	274	-20	274	274	112	119	-7	156	177	-19
<i>nasus</i>	333	312	268	+44	268	268	96	120	-24	201	179	+22
Lake Ontario (Pleasant Point)...	410	267	287	-20	287	287	118	122	-4	152	172	-20

ever, the greatly shortened snout of specimens from such localities as Kittigasuit and Arctic Red River that produces the relatively broad maxillary. It is the shortening of the snout that is the significant feature of these fish and as we have seen, there is every gradation in this character between the short snout of Kittigasuit fish and the long-snouted Nipigon fish.

A glance at table 3 is sufficient to show the wide variation in body depth among northwestern whitefish. Kittigasuit and Peel River specimens are the only ones having deeper bodies than those from Lake Nipigon. The Arctic Red River specimens are of the same depth as Lake Nipigon specimens. All of the others have less deep bodies, as have also the Lake Ontario whitefish. The specimen of *nasus* had by far the deepest body of any of the specimens examined (+44), followed in order by Peel River (+24), Kittigasuit (+9), Arctic Red River (0), Squanga Lake (-2), *nelsonii* and Lake Ontario (-20), Yukon River (-27), Baker Lake (-36) and *kennicotti* (Alaska) (-46).

In a number of areas in the northwest, a "crooked back" or "humpback" whitefish is distinguished from the more common form by the local people. The "crooked back" is similar to the humpback or bowback whitefish of Lake Erie in possessing a pronounced hump at the nape. Richardson (1823) noted this tendency in the northwestern whitefish remarking "When very fat the shape of the fish is somewhat distorted, as it acquires a hump immediately behind the head." My correspondent, Mr. K. H. Lang, believes that the humpbacks run by themselves and do not breed with the common whitefish. The flesh of the common whitefish, according to Mr. Lang, is slightly pinkish tinted, generally fat and firm; the spawn is pale yellow. The humpback, he says, has a more pointed snout, as well as a more pronounced hump. Its flesh is pale whitish and dry and inclined to be mushy when boiled; the spawn has a strong orange tint. According to Mr. Lang, the Eskimos distinguish between the two forms, calling the common whitefish *Anaklik* and the humpback, *Pekoktuk*.

Dall (1871) also reported a difference in the nature of the flesh between the humpback and broad whitefish. The former he described as "rather bony and inferior in flavor. It is generally used as dog feed, except in times of scarcity." The broad whitefish he said was "usually very fat and excellent eating."

Both common and humpback whitefish as recognized locally were among the specimens sent me by Mr. Lang but I was unable to find any other characters such as a different number of gill-rakers or scales correlated with the humpbacked condition. It is possible that, if the two forms are distinct, they belong to what may be regarded as physiological races

and have not diverged morphologically sufficiently widely to be recognizable in view of the wide morphological variation exhibited by the whitefishes. Further research based on more adequate material may reveal differences between the so-called humpback and common whitefish of the northwest that merit nomenclatural recognition, but such differences are not shown by the material now available. The humpback whitefish of Alaska was given the name *nelsonii* by Bean (1885a) presumably on the basis of its humpbacked condition. However in his key (1884) he distinguished *clupeiformis* and *nelsonii* as follows:

Nape arched and thick, gill-rakers 26-29.....*clupeiformis*
 Nape arched and much compressed; gill-rakers 26.....*nelsonii*

It would therefore appear that the compression of the arched nape was the feature by which he distinguished the two forms. I have not seen the type of *nelsonii* but none of the other northwestern whitefish which I have examined can be distinguished from Great Lake specimens on the basis of the compression of the arched nape.

The length of the caudal peduncle is one of the characters which show wide variation among the specimens examined. All were shorter than this character in Lake Nipigon specimens. The shortest was the specimen *nasus* (-24). The others in order of increasing length were *kennicotti* (Alaska) (-21), Kittigasuit and Yukon River (-13), Peel River (-12), Squanga Lake (-11), *nelsonii* (-7), Arctic Red River (-6), Lake Ontario (-4), Baker Lake (-2).

Length of fins is another quite variable character. There are long-finned and short-finned variants. Usually all the fins vary together,—all the fins will be long or all short. In table 3 the height of the dorsal fin has been taken as an index of fin length. Again the specimen of *nasus* departs farthest from the Lake Nipigon form which we are using as a standard. It is the longest-finned specimen examined (+22). In order of decreasing fin size, we have Peel River (+15), Yukon River (+11), Arctic Red River (+9); Baker Lake and Thelon River equal in fin length to Lake Nipigon specimens and the following with shorter fins,—Kittigasuit (-3), *kennicotti* (Alaska) (-9), Squanga Lake (-11), *nelsonii* (-19) and Lake Ontario with the shortest fins (-20). It is indoubtedly significant that the specimens from rivers have much longer fins than those from lakes.

The number of pyloric caeca is the most variable of all the characters investigated in the collections examined in connection with this study. Pyloric caeca numbers of five specimens from Arctic Red River were 146, 149, 153, 155 and 194; of five from Baker Lake 150, 171, 189, 194, 196; and of six from Hudson Bay 140, 152, 155, 170, 186, 222. Number

TABLE No. 4
LOCALITIES ARRANGED IN ORDER OF ASCENDING NUMBER OR SIZE OF A NUMBER OF BODY PARTS OF *Coregonus*
FROM DIFFERENT LOCALITIES

Gill-rakers	Scales	Head length	Eye	Snout	Body depth	Caud. ped. L.	Dorsal fin
<i>kennicottii</i>	Baker Lake	<i>nasus</i>	Peel River	<i>nasus</i>	<i>kennicottii</i>	<i>nasus</i>	Lake Ontario
<i>nelsonii</i>	<i>nelsonii</i>	Arctic Red R.	Lake Ontario	Kittigasuit	Baker Lake	<i>kennicottii</i>	<i>nelsonii</i>
<i>nasus</i>	Lake Nipigon	Lake Ontario	Baker Lake	<i>kennicottii</i>	Yukon River	Kittigasuit	Squanga Lake.
Yukon River	Yukon River	Yukon River	<i>nasus</i>	Arctic Red R.	Lake Ontario	Yukon River	<i>kennicottii</i>
Kittigasuit	Peel River	<i>kennicottii</i>	Yukon River	Peel River	<i>nelsonii</i>	Peel River	Kittigasuit
Peel River	Arctic Red R.	<i>nelsonii</i>	Arctic Red R.	<i>nelsonii</i>	Squanga Lake	Squanga Lake	Lake Nipigon
Arctic Red R.	Lake Ontario	Kittigasuit	<i>nelsonii</i>	Squanga Lake	Arctic Red R.	<i>nelsonii</i>	Baker Lake
Baker Lake	Kittigasuit	Baker Lake	Lake Nipigon	Lake Ontario	Lake Nipigon	Arctic Red R.	Arctic Red R.
Lake Nipigon	<i>kennicottii</i>	Squanga Lake	Kittigasuit	Baker Lake	Kittigasuit	Lake Ontario	Yukon River
Lake Ontario	Squanga Lake	Peel River	Squanga Lake	Yukon River	Peel River	Baker Lake	Peel River
Squanga Lake	<i>nasus</i>	Lake Nipigon	<i>kennicottii</i>	Lake Nipigon	<i>nasus</i>	Lake Nipigon	<i>nasus</i>

of pyloric caeca would therefore appear to be of little value in the recognition of species.

There are no differences of the sort which characterize species between any of the northwestern whitefish or between any of them and Great Lakes whitefish. In an effort to indicate the nature and extent of the differences between the populations we have been considering, table 4 has been constructed. For each character,—gill-rakers, scale number, head length, etc.,—the collections have been listed in order of size, with the one having the lowest number or measurement at the top and the one with the highest at the bottom. This table does not indicate among northwestern whitefish any correlation of characters such as occurs in one species as compared with another. (See discussion of differences characterizing *Leucichthys pusillus* as compared with *L. laurettae*).

Table 5 indicates in the first column the number of times a certain collection appears at the top or bottom of a list in table 4. A place at the top or bottom of such a list indicates an extreme variation of the character in question as compared with the other collections considered.

TABLE No. 5

THE EXTENT OF DIVERGENCE BETWEEN *Coregonus* FROM DIFFERENT LOCALITIES

Number of times in Table 4 whitefish from localities indicated are:

At top or bottom of list	Next to <i>nasus</i>
<i>kennicotti</i> 3	<i>kennicotti</i> 1
<i>nelsonii</i> 0	<i>nelsonii</i> 1
<i>nasus</i> 6	Yukon River.....2
Yukon River.....0	Kittigasuit.....1
Kittigasuit.....0	Peel River.....2
Peel River.....1	Arctic Red River.....1
Arctic Red River.....0	Baker River.....1
Baker Lake.....1	Lake Nipigon.....0
Lake Nipigon.....3	Lake Ontario.....0
Lake Ontario.....1	Squanga Lake.....1
Squanga Lake.....1	

There are eight lists, so that eight is the maximum number of times a collection could appear at the top or bottom. The fact that *nasus* appears in such a position six times whereas no other collection appears there more than three times indicates that *nasus* diverges more widely from the others than any of the others do from one another. In the second column of table 5 the number of times a collection appears next to *nasus* in table 4 is indicated. It is believed to be significant that the Peel and Yukon River collections were nearest to *nasus* in two characters each, while Lake Nipigon and Lake Ontario specimens are never next to it. Although the Kittigasuit specimens are in only one character next

to *nasus*, they are only once removed in three other cases—in one of these cases *kennicotti* is interposed, and in the other two Peel River and Yukon River collections. In view of the fact that only two complete specimens from Kittigasuit were available, some of the differences between them and the other collections are probably not significant. On the basis of the characters here discussed, the specimens of *kennicotti* and the collections from the Peel and Yukon Rivers and from Kittigasuit approach *nasus* more closely than do the specimens of *nelsonii* or the collections from Arctic Red River, Baker Lake and Squanga Lake, while the Lake Nipigon and Lake Ontario collections are the most widely divergent.

A study of table 4 also shows the lack of a geographical trend in most of the characters considered. Gill-raker number is the only character in which any approach to a geographical trend is apparent. The possession by Squanga Lake specimens of the highest number of gill-rakers is the only departure from what is essentially a northwest-southeast trend in increasing number of gill-rakers. The question naturally arises as to whether the variation in some or all of the other characters may not be due to the effect of ecological conditions. It has already been noted that the collections from rivers all have longer fins than those from lakes. In Lake Nipigon (Dymond 1926) it was found that the eyes of all species of *Leucichthys* (5) found in Ombabika Bay were larger than those of corresponding species found in the lake proper. This condition is probably related to the slightly turbid conditions of the water of the bay.

COREGONUS NASUS, C. ODONOGHUEI AND C. ATIKAMEG

The wide variation in body proportions exhibited by whitefish from different ecological conditions misled Bajkov (1927, 1930, 1933) into the recognition in Western Canada of a number of distinct species: *nasus*, *odonoghuei*, *atikameg* and *atikameg manitobensis*.

In 1927 Bajkov recorded *nasus* from Beauvert Lake in the Athabasca River system, a tributary of the Mackenzie. His specimen has not been available for study and it is difficult to translate his measurements into the proportionate measurements used in this paper since he does not give the standard length of the specimen. In any case, his specimen was an unusually large one.

Through the kindness of Dr. D. S. Rawson of the University of Saskatchewan, I have had the opportunity of examining a specimen of Beauvert Lake *Coregonus*. Following are the proportionate measurements and counts for this specimen. The measurements of Lake Nipigon specimens of corresponding length are given in parentheses,—standard length 44 cm., scales 76, gill-rakers 26, branchiostegals 9, head length

191 (210), eye 38 (39), snout 53 (59), interorbital 59 (59), maxillary 54 (65), body depth 275 (300), body width 152, caudal peduncle length 98 (127), caudal peduncle depth 93 (86), dorsal rays 14, height 170 (168), base 141, anal rays 14, height 125 (124), base 136, pectoral length 188 (203), ventral 173 (178), adipose 73.

While in two of the eight characters considered in table 4 this Beauvert Lake specimen diverges more widely than *nasus* from the other collections included in the table, in a number of others it departs widely from *nasus*. For instance, it has a lower number of scales than any of those included, whereas *nasus* has the largest number. In number of gill-rakers, perhaps the most significant character for taxonomic purposes, it stands between the Baker Lake collection and those from the Great Lakes, and diverges from *nasus* more than any of the other northwestern populations except that from Squanga Lake. Unless all the collections here considered are regarded as variants of *nasus*, the Beauvert Lake whitefish cannot be considered as belonging to that species. Berg (1932, 1936) has already pointed out that the specimen described by Bajkov had more gill-rakers and fewer scales than typical *nasus* and proposed that it be regarded as a subspecies *canadensis*. The question of recognizing subspecies in *Coregonus* will be discussed later.

Coregonus odonoghuei from Clear Lake, Riding Mountains, according to Bajkov (1930), differs from *clupeaformis* "in the more slender body, longer caudal peduncle, larger head and the presence of many black spots on the fins and scales." The depth of the body he gives as 4.5 in length as against only 3.2 in *clupeaformis*. He apparently overlooks the fact that length of body to him is to the end of the caudal rays, whereas American workers have usually made their calculations on the basis of standard length. Recalculations of depth to standard length of the ten specimens for which Bajkov gives measurements yield the following proportions: .224, .289, .262, .261, .250, .240, .238, .246, .246, .243, average .250; average standard length 345. To arrive at these proportions standard lengths have been calculated from comparisons of standard length and total length of specimens from other localities and may not be entirely accurate for Clear Lake fish.

The depth of Lake Nipigon whitefish of the same average length as the above ten Clear Lake fish is 270. The difference is therefore — 20. By reference to table 3, it will be seen that several populations of northwest whitefish have even more slender bodies than have Clear Lake whitefish.

The gill-rakers of *odonoghuei* according to Bajkov number from 24 to 29, average 26.2. Attention has already been drawn to the fact that there is a gradation in gill-raker counts from the Great Lakes north-

westward. These Clear Lake specimens fit perfectly into this graded series. The scales of Bajkov's specimens ranged from 75 to 85 in the lateral line, average 79.9. For the Great Lakes, Koelz (1929) gives the following: Lake Nipigon 78-85, Superior 81-86, Huron 80-88, Erie 77-86, Ontario 80-88.

It appears obvious from a consideration of the above facts that *odonoghuei* is merely one of the numerous ecological forms of *clupeaformis*.

C. atikameg, Bajkov said, was "an anadromous species from Hudson Bay Very abundant along the shores of Hudson's Bay. In August it begins to ascend the rivers for spawning". It was said to differ from *clupeaformis* in its slender body and very dark colour . . . head, eye and adipose fin, very much larger . . . pectoral fins very long . . . caudal peduncle short, head flat dorsally, snout long and obliquely cut down backwards, maxillary long and nearly reaching the eye, the circum-orbital bones were said to be seven instead of usually six in *clupeaformis*. The gill-rakers were indicated as averaging 25.6 and lateral line scales 83.

C. atikameg manitobensis, Bajkov described as "a freshwater form of the above-mentioned fish . . . very abundant in all deep lakes of northern Manitoba, north of the Pas . . . also in the Nelson and Churchill rivers and probably in all other rivers north of Churchill in the Northwest Territories". Its colour, shape and proportionate measurements were said to be "very similar to the anadromous form". Its gill-rakers were given as 25.6 and scales as 76.3. How to distinguish the subspecies *manitobensis* from the typical form when both were in freshwater was not stated. It is hardly necessary to say that colour is influenced by the character of the waters in which fish live. In Black Sturgeon Lake near Lake Nipigon I have seen whitefish almost jet black (Dymond 1926, pp. 10-11). The formalin in which Black Sturgeon Lake specimens were preserved was quite dark-coloured after they had been in it a few days. The water of this lake is of a very dark brown colour.

The present author (Dymond, 1933) has already discussed the relationship of the *Coregonus* of Hudson and James Bays to that of the Great Lakes and decided that they represent the same species. The following comparison of body measurements of specimens from Hudson Bay and Lake Nipigon are quoted from the previous publication.

	<i>Head</i>	<i>Body depth</i>	<i>Caudal length</i>	<i>peduncle depth</i>	<i>Pectoral fin length</i>
Hudson Bay . . .	21.4	25.7	11.7	8.9	17.4
Lake Nipigon . .	21.4	26.3	12.2	8.4	18.4

Scales were found to be 74-82 in Hudson Bay as compared with 78-85 in Lake Nipigon and 80-88 in Lake Ontario.

C. atikameg is undoubtedly synonymous with *clupeaformis*.

SUBSPECIES IN *COREGONUS*

Coregonus varies from one locality to another in all its body proportions and in such characters as number of gill-rakers, scales, branchiostegals and fin rays. Most of these characters, however, appear to show ecological rather than geographical variation. We have seen that the nearest approach to a geographical cline (Huxley 1938, 1939) is found in number of gill-rakers. There is a rather gradual decrease in number of gill-rakers from the Great Lakes northwestward to the Mackenzie River and perhaps beyond. On the basis of such differences, we might regard the whitefish of the Mackenzie River region as constituting a subspecies for which the name *kennicotti* is available. In his description of this form Bean mentioned, although he did not emphasize, its small gill-raker count. There is more evidence than that included in the present paper that whitefish of the Hudson Bay drainage have a characteristic gill-raker range intermediate between Great Lakes and northwestern whitefish. On the basis of such data, three subspecies might be recognized: *clupeaformis*, *hudsonius* and *kennicotti*. Complications would arise, however, when one tried to name on this basis the Squanga Lake whitefish which as we have seen have a gill-raker number characteristic of the Great Lakes. It would be more logical to regard this population as a fourth subspecies than to lump it with the Great Lakes form. It is unlikely that Squanga Lake is the only population differing markedly from those in its general area, so that we should ultimately have to recognize a very large number of subspecies, many of them with a sort of crazy-quilt pattern of distribution. Koelz (1931) recognizes among *Coregonus* from 36 lakes of northeastern America from which he had specimens, six subspecies other than typical *clupeaformis*. On the same ratio, it would probably be possible to erect several hundreds, if not several thousands, of subspecies of North American *Coregonus*, for there are undoubtedly many thousands of lakes across northern Canada containing whitefish. There probably exist whitefish exhibiting almost every possible combination and permutation of characters which vary with the environment. Until some relationship has been worked out between environmental factors and body characters of *Coregonus*, the description of subspecies on the basis of the characters of individual local populations adds to confusion rather than to enlightenment.

RELATIONSHIP OF AMERICAN AND ASIATIC WHITEFISH

There is still the question as to the relationship between the American and Asiatic whitefish. It has been shown that in gill-raker count, perhaps the most satisfactory character on which to base taxonomic distinctions, *nasus*, one of the Siberian whitefishes, represents a continuation westward of a fairly smooth trend from the Great Lakes north-westward. On the basis of this character alone, one would scarcely be justified in drawing a hard and fast line between Asiatic and American whitefish. However, *nasus* is practically, if not actually, at one end of the series in gill-raker count and at the other end in number of scales. In a number of its body proportions it differs widely from most American forms, although occasional populations, as for example the Beauvert Lake form, are even more extreme than *nasus* in such characters as body depth and caudal peduncle length. It is obvious therefore that *clupeaformis* is the American representative of *nasus*. It would probably be as logical to regard *clupeaformis* as a subspecies of *nasus* as it is to regard *quadrilateralis* as a subspecies of the Asiatic round whitefish *cyindraceus* as proposed by Berg (1936).

However, in the writer's opinion it is premature to adopt the name *nasus* for the common whitefish of America. The *Coregonus* type is spread throughout the northern part of the northern hemisphere from Ireland to the Maritime Provinces of Canada. Within this wide range, it appears in numerous forms, the taxonomic relationships of which we are still far from understanding. Smitt, as long ago as 1893 drew attention to "the peculiarities which seem to characterize the Gwyniad (the European whitefish) where it lives under exceptional conditions However unlike the differentiation of form may be in localities at a distance from each other, variations as great may be observed in the same water, the extremes of the form-series appearing side by side. No wonder then that ichthyologists have failed sharply to define local varieties, though a more than adequate number of names have been proposed to this end". He concludes his discussion, which includes a consideration of *Coregonus* in Asia, with the remark that "we know of no specific difference between *C. clupeaformis* and our European Gwyniad". Until a more adequate understanding of the relationship of the various forms of *Coregonus* is arrived at, I suggest that *clupeaformis* be retained as the name of the American representative.

According to Dall (1870, 1871) and Bean (1884) the Alaskan whitefish, to which the name *kennicotti* was later applied, i.e., the so-called broad whitefish, was in the early days of American possession of Alaska referred to as the muksun. Muksun is the common and also the specific

name of one of the species of *Coregonus* occurring in Siberia. Berg (1932) gives its occurrence as "From freshwater parts of the Arctic Ocean it enters rivers from the Pechora to Kolima. More common in the lower courses of the rivers". Its gill-rakers, which are said to number 44 to 65, are much more numerous than those of any American *Coregonus*. Its resemblance to our forms must be largely superficial.

HABITS AND ECONOMICS

For the following information on the habits and economics of the whitefish of the lower Mackenzie area I am indebted to Mr. K. H. Lang, who has spent many years in that region.

In that area whitefish make up a large part of the food of the people and of their sledge dogs; they are preferred to all other species. They occasionally exceed twenty pounds in weight although ten pounds is usually considered a very large fish. Four to five pounds is the average size.

It is found in most of the channels and lakes of the delta region. Some are taken in quite brackish water along the coast north at Tuk-tuyaktok (Port Brabant) although not in great numbers. They are caught in nets set in the back eddy of the river channels and in narrows between lakes; four and a half and five inch mesh are generally used.

In winter they are caught in nets set under the ice and just piled up and frozen. In summer some are put in pits in the ground for dog food. If the pits are deep and the flies kept out, they make excellent dog food. Such fish, when frozen, are often eaten by the Eskimos too and considered by them as quite a delicacy. Mr. Lang says they once told him it tastes "all same sardines". Sardines are "white man ippy fish" in Eskimo. With reference to the fish preserved in pits Mr. Lang remarks: "I can't vouch for the taste but, believe me, they don't smell like sardines." In summer great numbers of fish are also dried and smoked for use in winter as food for both humans and dogs. The head and entrails are removed and the backbone cut loose from the flesh. The fish is then scored with a knife so that it will dry in the sun in three or four days. After being smoked for about 48 hours, they are ready to bale up. A four or five pound fish will then weigh about a pound.

As an example of fishing in this area, Mr. Lang cites his experience at his camp 3 on the East Branch during the summer of 1936. From July 10 to August 15 he caught approximately 5000 fish, of which 83 per cent were whitefish, the other 17 per cent being pike, inconnu and crooked-back whitefish in about equal numbers. The fish did not start running strongly until about July 18, but after that date the run was steady. In three nets from 180 to 220 were caught each day—all that

could be dressed for drying. The fish travelled upstream at the rate of four miles a day. The rate was determined by comparing notes with fishermen downstream. This run occurs every year.

At this season, the fish are quite fat and full of maturing ova. The largest fish caught that year was 13 pounds; smaller than the record fish in most years. The fish were brightly coloured, showing that they had recently come from some clear water lake. The river water is turbid, and fish soon become dull and pale after spending some time in it. After about six weeks, this yearly run slackens and fish are not caught in numbers again until after freeze-up when a short run occurs under the ice.

PROSOPIMUM

PROSOPIMUM CYLINDRACEUM

Round whitefish are widely distributed in northern Asia and northern North America from the Yenisei River in Siberia to New Brunswick and Maine. The common North American form has been known under the specific name *quadrilateralis* since 1823 when Richardson described under that name specimens from "small rivers about Fort Enterprise and the Arctic Sea". The Siberian species is known as *cylindraceus*. Recently Berg (1936) has suggested that the Asiatic and American forms are so similar as to be properly regarded as of the same species. He says "according to Koelz (1927) the number of scales in the lateral line in numerous specimens from the Great Lakes and Lake Nipigon is (74) 84 to 95 (100) and the number of gill-rakers is usually 16 to 18; both averaging somewhat fewer than in typical *cylindraceus*. So far as known these are the only differences between *cylindraceus* and *quadrilateralis*." Berg gives the lateral line scales of *cylindraceus* as 89-106, average 96, and gill-rakers as usually 18 to 20.

In comparing *quadrilateralis* and *cylindraceus*, it will be noticed that Berg takes Great Lakes and Lake Nipigon specimens as representing *quadrilateralis*, whereas this name properly belongs to a Northwest Territory form. Efforts to secure specimens from the type locality have been unsuccessful. There is no longer any settlement at the site of Fort Enterprise.

Table 6 gives proportionate measurements and counts of gill-rakers, scales, fin rays, etc. of specimens from the general area of the type locality. For comparison, similar measurements and counts for Lake Ontario specimens are also included.

It will be noticed that northwest specimens have more scales and gill-rakers than Lake Ontario specimens. Altogether, 14 specimens from the northwest were examined. These fourteen average 92.6 scales (86-100) and 18.1 (16-20) gill-rakers. Koeltz (1929) gives actual counts for 32

TABLE No. 6
PROPORTIONATE MEASUREMENTS AND COUNTS OF BODY PARTS OF *Prosopium cylindraceum* FROM DIFFERENT LOCALITIES

Number of specimens	Great Bear Lake 4		Rutledge River† 3		Baker Lake 5		Baker Lake No. 10781	Yukon River 1	Lake Ontario 10	Churchill No. 7342 ♂	Hudson Bay No. 7343 ♀
	Average	Range	Average	Range	Average	Range					
Standard Length.....	316	300-330	421	400-437	345	325-379	283	315	322	395	292
Scales.....	95	90-100	92	89-97	92	86-99	92	90	86	87	89
Gill-rakers.....	18.8	18- 19	19	18- 20	17	16- 18	18	18	17.2	16	18
Branchiostegals.....	8	8	6.7	6- 7	6.6	6- 7	8	8	7.3	7	7
Pyloric caeca.....	100.8	82-116	91	81-102	90.4	76-105	74	104	84.3†		
Head length.....	184	177-195	204	202-206	182	180-185	154	184	188	203	195
Head depth.....	121	115-124	136	129-140	116	114-119	125	121	121	133	126
Eye.....	37	35- 38	40	39- 41	36.6	36- 37	40	38	44	41	43
Snout.....	50	46- 53	58	56- 61	47.6	45- 50	47	48	49	53	47
Interorbital.....	56	52- 62	70	68- 71	54	52- 55	53	54	57	63	55
Maxillary.....	43	38- 46	47.7	47- 48	43	39- 48	47	42	42	51	42
Body depth.....	206	182-221	230	213-240	210	200-221	179	222	204	161	188
Body width.....	144	133-154	155	148-165	138	129-146	144	159	127	101	120
Caudal peduncle											
Length.....	149	136-178	124	118-133	148	133-161	151	152	145	140	137
Depth.....	77	76- 78	87	85- 88	72	69- 80	74	73	70	84	76
Dorsal rays.....	13.5	13- 14	13	13	13.4	13- 14	14	13	13.4	13	12
Dorsal height.....	145	138-153	167	160-173	132	124-137	133	143	141	146	154
Dorsal base.....	127	122-132	120	114-129	116	108-137	120	124	108	116	119
Anal rays.....	12.5	12- 13	12.3	12- 13	12.4	12- 13	13	13	11	11	11
Anal height.....	119	114-123	136	132-141	110	101-114	107	124	101	134	135
Anal base.....	93	87- 97	93	87- 98	88	85- 94	92	94	75	94	86
Pectoral length.....	154	145-167	186	183-191	155	151-158	154	149	154	153*	164
Ventral length.....	139	132-145	162	153-167	133	126-149	130	133	132	143	147
Adipose length.....	70	61- 75	68	61- 73	61	58- 65	70	84	61	62	75

*Decidedly falcate.
†Range 50-102.
‡Tributary to Great Slave Lake via Taltson River.

specimens from the Great Lakes. These average 89 (74-97) scales and 17.1 (15-19) gill-rakers. These results indicate that northwest specimens in number of scales and gill-rakers approach *cyindraceus* more closely than do Great Lakes specimens. In respect of these characters the forms under consideration appear to represent a cline (Huxley 1938, 1939). Their separation into a Siberian and a North American subspecies would appear to be merely arbitrary. Berg's reference to a single specimen from the Anadyr River having 86-88 scales and 18 gill-rakers indicates that even in Asia a trend towards lowered scale and gill-raker counts occurs. In America the trend towards lowered scale and gill-raker counts appears to be continued eastward beyond the Great Lakes. Three specimens from the Restigouche River, New Brunswick, average 87 scales and 16.3 gill-rakers.

Prosopium is subject to considerable variation from one locality to another even in the same region. This is especially evident in body form and length of fins as is shown by a comparison of the specimens from Fort Smith with those from Great Bear Lake. The Fort Smith specimens have considerably longer, deeper and wider heads, deeper and wider bodies, shorter and deeper caudal peduncles and longer fins. It should be noted however, that the Fort Smith specimens are much larger than those from Great Bear Lake. Two specimens from Churchill, Hudson Bay, (Table 6) varied widely from the usual type. They were long, slender and compressed with overhanging snouts. The smallest of the five specimens from Baker Lake, listed separately in table 6, No. 10781, had a much shorter but deeper head and a more slender body than the others. All of these abnormal specimens, however, had the usual number of scales and gill-rakers. It is probable that *Prosopium* is even more subject to environmental modification than *Coregonus* or *Leucichthys*. The occurrence in a number of collections of one or more specimens of deeper and more compressed form with shorter caudal peduncle may have more than ecological significance but the present collection is not large enough to warrant any conclusion in this connection.

Berg (1932) refers to Borisov's observations on the differences between the *Prosopium* of the upper and of the lower part of the Lena River in Siberia. Those from the lower Lena have a less deep body, 15.9% of the length to the end of the middle rays of the caudal, as compared with 16.7% in the case of those from the upper Lena. Lower Lena specimens also have wider heads and shorter snouts. Specimens from the upper Lena are said to have a more rapid growth rate than those from the lower Lena.

The specimen described by Harper and Nichols (1919) under the name *preblei* appears to have been a typical representative of *cyldraceum*. The type specimen of *preblei* could not be located in the National Museum of Canada, where it is said to have been stored. The similarity of this specimen to those included in table 6 is shown by the following proportionate measurements derived from Harper and Nichols's description. Standard length 470, scales 93, gill-rakers 17, branchiostegals 8, head length 187, eye 32 (the deviation in this character is undoubtedly due to a different method in making the measurement. This opinion is confirmed by a re-measurement of the three specimens of *Leucichthys* described in the same paper, which were available for measurement); snout 55, interorbital 60, maxillary 47, body depth 213, 14 developed dorsal rays, dorsal height 138, 11 developed anal rays, anal height 128, anal base 94, pectoral length 153, ventral length 130.

A comparison of *quadrilaterale* and *williamsoni* has been made by Dymond (1936).

PROSOPIMUM OREGONIUM

Six specimens from Lesser Slave Lake, Alberta, appear to belong to the species *oregonium* described by Jordan and Snyder (1909) from the McKenzie River, Oregon.

Proportionate measurements and counts of body parts of these six specimens and of the type which I was privileged to measure in the United States National Museum are given in table 7. There is considerable difference in body proportions between the Lesser Slave Lake specimens and the type. The type of *oregonium* has a longer and wider head with correspondingly longer snout and maxillary, more compressed and slender body and more slender caudal peduncle. It has also a much larger adipose, one of the characters which distinguishes *oregonium*. While the adipose of the Lesser Slave Lake specimens is not as large as that of the type of *oregonium*, it is very much larger than that of any *cyldraceum* included in table 6.

In view of the wide variation in body proportions shown by *Prosopium* as cited in the discussion of *quadrilaterale* above, the variation from the type of *oregonium* shown by the Lesser Slave Lake specimens is not considered to indicate that they belong to a different species, especially in view of the similarity in gill-raker number, the most stable coregonine character. As pointed out in the discussion of *Coregonus*, until the effect of various ecological factors on the morphometry of coregonines has been worked out, it adds to confusion rather than to elucidation to multiply species and subspecies.

TABLE No. 7

PROPORTIONATE MEASUREMENTS AND COUNTS OF BODY PARTS OF *Prosopium oregonium* FROM LESSER SLAVE LAKE, ALBERTA AND OF THE TYPE No. 62987, U.S. NAT. MUSEUM

	13248	13249	3346	13251	13250	13252	TYPE
Length length.	377	353	340	324	321	244	405
Scales.....	88	84	77	83	81	82	90
Gill-rakers.....	22	22	23	24	22	22	22*
Branchiostegals....	8	8	8	8	8	9	9
Pyloric caeca.....	102	95	118	82	96		
Head length:.....	211	214	209	221	206	211	259
Head depth.....	149	147	150	154	151	137	153
Eye.....	40	41	47	46	44	47	40
Snout.....	72	68	62	77	59	59	97
Interorbital.....	63	61	47	66	62	47	69
Maxillary.....	63	61	58	69	53	53	84
Body depth.....	295	255	268	250	280	205	200
Body width.....	194	166	150	204	193	129	107
Caudal peduncle							
Length.....	115	119	135	122	143	125	136
Depth.....	84	82	82	89	88	78	67
Dorsal rays.....	14	14	14	14	14	15	15
Dorsal height.....	152	169	168	154	162	166	
Dorsal base.....	135	127	128	133	140	135	
Anal rays.....	13	12	12	13	14	13	15
Anal height.....	143	146	150	149	147	143	
Anal base.....	105	105	99	100	101	102	
Pectoral length....	170	170	187	173	178	178	182
Ventral length.....	152	157	174	157	156	156	170
Adipose length....	97	102	97	113	107	111	137
Sex.....	female	female	female	male	female		

*The gill arch was not removed, but so far as could be determined without removing the arch, there were 22 gill-rakers

PROSOPIMUM COULTERII

Prosopium coulterii described by Eigenmann and Eigenmann (1892) from the Kicking Horse River at Field, British Columbia, and recorded (Eigenmann 1895) also from Golden, British Columbia, has not been reported from the Northwest Territories or Yukon, although its range has been extended to include both Washington and Alaska. Jordan and Snyder (1909) record it from Diamond Lake, Stevens County, Washington, and Kendall (1917; 1921) from two localities in Alaska,—Second Lake and the stream connecting it with First Lake, presumably near Chignik, and Lake Aleknagik. In his 1921 paper Kendall suggests that this species may have been comprised in other collections and confused with the round whitefish. He believes, for instance, that the figure of the head of *Coregonus quadrilateralis* from Port Halkett shown by

Günther (1866 p. 176) may be *coulterii*. Incidentally he remarks that there are two Port Halketts, one in British Columbia and one at the mouth of the Mackenzie River.

Following is a description based on measurements of one of Eigenmann's specimens which I made in the British Museum (Natural History). Proportions indicated as percentages of the standard length, which in the case of this specimen was 155 mm. Head length 21.3, eye diameter 5.8, snout 5.2, interorbital width 6.5, maxillary 6.0, dorsal rays 9, dorsal height 19.0, dorsal base 11.0, anal rays 10, anal height 18.4, anal base 10.0, pectoral length 20.3, ventral length 18.7, adipose length 8.1, scales 59.

LEUCICHTHYS

In contrast to the condition in *Coregonus* and *Prosopium* in which no body of water appears to have more than a single species of each genus, two or more species of *Leucichthys* commonly occur together. Koelz (1929) recognizes seven species of this genus in Lake Huron. When combined with this condition we have the intraspecific variation from one body of water to another, it is to be expected that the number of species that have been described is greater in *Leucichthys* than in either *Coregonus* or *Prosopium*.

In his 1823 account of the fishes of northwestern Canada, Richardson doubtfully identified the lake herrings met with as *artedi*. He said they were found in most of the lakes and that he had caught a few in the sea at the mouth of the Coppermine River. In his 1836 account, he designated the lake herring which he found so abundant in Great Bear Lake as *Salmo* (*Coregonus*) *lucidus*.

That the lake herrings found in and about the mouths of the rivers of Alaska and northwestern Canada have long been recognized as belonging to two species is mentioned below in comparing *laurettae* and *pusillus*. These names were given to these two species by Bean in 1882 and 1889 respectively.

Scofield in 1899 gave the name *alascanus* to three specimens taken in northern Alaska, one in salt water at Point Hope and two in brackish water at Grantley Harbour. They were, he said, nearest related to *artedi* but differed considerable in number of gill-rakers.

Harper and Nichols (1919) gave the names *entomophagus*, *athabascae* and *macrognathus* to lake herrings found in the Tazin River, Lake Athabaska and Great Slave Lake respectively.

The type of *lucidus* is not in existence and I have been unable to locate the type of *alascanus*. It is not in the United States National Museum nor in the Natural History Museum of Stanford University.

I have examined the types of all the other species mentioned above,—*laurettae* and *pusillus* in the United States National Museum, and *entomophagus*, *athabasca* and *macrognathus* in the National Museum of Canada. In addition I have examined 54 specimens from northwestern Canada, as already listed.

LEUCICHTHYS LAURETTAE and *L. PUSILLUS*

The lake herrings of the Mackenzie delta, so far as the collections which I have examined are concerned, belong to two species which I identify as *laurettae* and *pusillus*.

Table 8 presents the proportionate measurements of the type specimens, as well as those of collections from various places in the Mackenzie region. It will be noticed that *pusillus*, as compared with *laurettae*, has fewer scales, more gill-rakers, shorter and less deep head (comparing specimens of equal size), larger eye, narrower interorbital, longer maxillary, deeper and more compressed body, longer fins, longer anal base (correlated with more anal rays) and fewer branchiostegals (*pusillus* usually has 8 branchiostegals whereas *laurettae* usually has 9). The most striking difference between the two species is in the size of eye; within the size range investigated *pusillus* has an eye with a proportionate measurement of more than 50, *laurettae* of less than 50. *pusillus* does not reach as large a size as *laurettae*. The small size of *pusillus* is mentioned by Bean in his original description. The largest individual he had seen was 11½ inches long. The largest individual in our collection is 288 mm. in standard length or 321 mm. (12 5/8 in.) to fork of tail. Our largest specimen of *laurettae*, a skin, is approximately 430 mm. in standard length or 460 mm. (18 1/8 in.) to fork of tail.

Additional characters distinguishing the two species are the almost vertical premaxillaries of most specimens of *laurettae*; the lower jaw is equal to or shorter than the upper. The premaxillaries of *pusillus* on the other hand are disposed at a wide angle to the vertical and the lower jaw is usually longer than the upper; the whole head is wedge-shaped, the upper and lower profiles straight and meeting at a sharp angle at the snout.

The fins of *pusillus* are darker, especially towards their distal ends, the ventral fins often quite black, those of *laurettae* light-coloured. The dark colour of the dorsal fin of *pusillus* is mentioned by Scofield (1899) as follows: "One of the specimens from the mouth of the Mackenzie is the only one that shows perfectly the black markings on the dorsal as given in the figure of a similar sea-run individual from northern Alaska (Whitefishes of America. Report of U.S. Commissioner of Fish and

TABLE No. 8
PROPORTIONATE MEASUREMENTS AND COUNTS OF BODY PARTS OF *Leucichthys*

Species	<i>pusillus</i> Type USNM 38366	15 ¹	<i>pusillus</i> Range	Type USNM 27695 ³	<i>laurettae</i> Range	5 ⁵	<i>laurettae</i> Range	6 ⁷	<i>laurettae</i> Range
Standard length.....	250	261	227-288	323	305-335	309	283-326	354	330-370
Scales.....	88	80	74-84	85.5	80-93	92 ⁶	84-99	91	88-93
Gill-rakers.....	49	45.5	42-48	37	33-43	42 ⁶	39-46	43.6	40-50
Branchiostegals.....	8	8	7-9 ²	9.5	8-10 ⁴	8.8 ⁶	8-9	8.8	8-9 ⁸
Head length.....	200	200	186-215	202	188-213	214	198-222	201	194-211
Head depth.....	134	129	116-139	133	125-140	147	129-177	135	126-142
Eye.....	56	55	51-59	43	42-46	45	42-47	44	41-46
Snout.....	50	48	43-55	47	45-49	50	47-55	47	44-48
Interorbital.....	54	47	43-53	58	57-59	59	55-61	61	58-63
Maxillary.....	68	74	69-79	66	63-69	69	63-72	66	64-72
Body depth.....	212	229	192-263	235	209-252	218	192-243	224	213-232
Body width.....	104	120	112-142	126	121-130	139	113-153	124	117-130
Caudal peduncle									
Length.....	120	120	106-142	123	110-139	124	108-129	120	112-131
Depth.....	80	81	73-89	76	73-82	77	69-83	73	68-77
Dorsal rays.....	12	12.4	12-13	13.8	13-15	13.8	13-14	13.2	13-14
Dorsal height.....	148	191	174-213	137	130-146	149	129-173	137	128-142
Dorsal base.....		116	96-128			131	126-141	123	119-127
Anal rays.....	14	14.5	13-16	13.7	13-14	13	12-14	13.7	13-14
Anal height.....		121	113-131	96	86-107	99	85-109	96	92-102
Anal base.....		133	120-155	115	104-128	106	98-114	111	103-119
Pectoral length.....	152	182	164-199	142	131-151	152	131-176	144	131-151
Ventral length.....	140	177	162-191	135	131-141	140	114-160	139	127-151
Adipose length.....	76	67	57-75	60	58-63	72	59-77	73	67-80

¹⁵ from Kidluit, 8 from Whitefish Stations and 2 from Tuktoyaktok (Port Brabant).

²¹³ had 8, 1 had 7 and 1 had 9.

³⁴ specimens with the same number, distinguished as A. B. C. D.

⁴³ had 10, 1 had 8.

⁵³ from Kidluit, 1 from Kittigasuit and 1 from Peel River.

⁶¹⁰ skins (8 from Whitefish Station and 1 each from Kidluit and Kittigasuit) had an average of 87 scales, 42 gill-rakers and 8.4 branchiostegals.

⁷Arctic Red River.

⁸⁵ had 9, 1 had 8.

Fisheries, 1894. Plate 23; also same plate in Cruise of Steamer Corwin).'' *L. pusillus* has the more compressed, *laurettae* the more terete body.

It will be noticed that there are considerable differences between the measurements of specimens from the Mackenzie region and those of the types especially in number of scales, fin lengths and in body depth and width of *pusillus*. We have already seen in the case of *Coregonus* that there is considerable variation in fin length between collections from different localities and that this character is probably correlated with ecological conditions. Body depth of the type is within the range shown by the 15 specimens from the Mackenzie region. The latter collection undoubtedly represents an ecological variation of *pusillus*.

That the lake herrings (*Leucichthys*) of the coastal areas of north-western America were of two quite different sorts was recognized long before Bean gave them the names *laurettae* (1882b) and *pusillus* (1889). Dall (1870) distinguished them as sea whitefish and Nulato whitefish. His 1871 list stated that the Nulato whitefish "is a small, thin, bony species, common near Nulato, on the Yukon, and is rarely more than half a pound in weight. It is of little use as food, and is principally abundant in summer". The other species which he designated simply as whitefish is described as "the most abundant and best flavoured species of *Coregonus* in most localities It rarely exceeds three pounds in weight and is the staple article of food in winter on the Yukon".

Bean (1882c, 1884, 1885b) lists *laurettae* and *Merckii* var. or "the species related to *C. Merckii*" as the members of this group that occur in Alaskan and adjacent waters. The latter is the species to which he later (1889) gave the name *pusillus*. Dall's estimate of it as "a small, thin, bony species" has been repeated by most subsequent authors.

Anderson (1913) also refers to tullibees of two sorts. One is known to the Mackenzie Eskimos as Pi-kok-tok, the other as An-Ark'hliik.

L. laurettae is called herring, fresh-water herring, lake herring and tullibee by Mr. Lang. It is a very common fish in the waters of the Mackenzie delta. It is well liked as human food and is equal to whitefish as dog food since it is fat most of the year. At Arctic Red River it is caught, dried and smoked in great numbers by the Indians every summer. In the fall it is caught at nearly all the fishing places. The reason it is not caught in greater numbers still is that it requires a special net, and since they are smaller than whitefish they do not bulk up so fast. It reaches a weight of $2\frac{1}{2}$ to 3 pounds but the average is a pound or less.

L. pusillus is a much smaller and less valuable species. It was called "big-eye" by Mr. Lang. It occurs in the Peel River right up to Fort McPherson but does not appear to be plentiful in the delta.

RELATIONSHIP TO ASIATIC SPECIES

These two species, *pusillus* and *laurettae*, are undoubtedly closely related to *sardinella* and *autumnalis* respectively of Siberia.

Berg's key of sub-genus *Leucichthys* (p. 198-199) abbreviated is as follows:

- A. Mouth superior, upper jaw shorter than lower, the lower sharply turned upwards; gill-rakers 36-54.
 - B. Antedorsal distance more than 42% of body length to end of middle rays of caudal..... *albula*
 - BB. Antedorsal distance less than 42% of body length to end of middle rays of caudal..... *sardinella*
- AA. Mouth terminal, upper jaw either equal to or longer than lower but never shorter.
 - C. Gill-rakers 25-31 (33)..... *tugun*
 - CC. Gill-rakers more than 33
 - D. Gill-rakers 35-51..... *autumnalis*
 - DD. Gill-rakers 56-68..... *peled*

L. albula is confined to Europe; *tugun* and *peled* have respectively fewer and more gill-rakers than either *pusillus* or *laurettae*. Among the synonyms of *sardinella*, Berg lists *merki* and *clupeoides*, and of *autumnalis*, *omul*.

Like *pusillus* and *laurettae*, *sardinella* and *autumnalis* occur in the mouths of Arctic rivers which they enter at spawning time. As already stated, Bean (1882c, 1884, 1885b) originally regarded the species to which he later gave the name *pusillus* as conspecific with *merki* (*sardinella*) and Berg (1932) describes *sardinella* as close to or identical with *pusillus*. As in *sardinella*, the lower jaw is usually longer than the upper.

Berg's (1932) descriptions do not include all of the details necessary to make a comparison of *sardinella* and *autumnalis* with *pusillus* and *laurettae*. The following comparisons indicate that *sardinella* as compared with *autumnalis* has fewer scales, more gill-rakers, and does not reach as large a size, which are parallel to differences in the same characters between *pusillus* and *laurettae*.

	<i>sardinella</i>	<i>autumnalis</i>
scales.....	71-97	86-111
gill-rakers.....	37-52	35-51 (aver. 45-46)
maximum length (to end middle rays of caudal).....	415 mm.	615 mm.

The similarity of *autumnalis* to *laurettae* is indicated by the vertical disposition of the premaxillaries shown in Berg's illustration of the

former (p. 212). When I examined a specimen of *omul* (*autumnalis*) from Lake Baikal, in the British Museum (Natural History), I noted "pre-maxillaries vertical as in *Coregonus* but not quite so high".

Berg gives the distribution of *sardinella* as "from the Ob to the Kolima, district of Chukotski peninsular and the Bering Sea; present in the Anadir; and *autumnalis* as "with the exception of the Ob, it enters from the sea into all the rivers which fall into the Arctic Ocean from the Mezen on the west to Chaun Bay (east of Kolima) on the east; Nova Zembla, Kolguev."

Moreover presumed hybrids similar to those regarded as crosses between *Stenodus* and *autumnalis* occur in the Delta region of the Mackenzie.

It seems certain, therefore, that *pusillus* and *laurettae* merely represent extensions eastward of *sardinella* and *autumnalis*. As these names are the older (*sardinella* 1848; *autumnalis* 1776), they should be recognized.

LEUCICHTHYS ALASCANUS

Although *L. alascanus* has not been recorded from Canadian waters, it should be discussed here since it is the only species of *Leucichthys* other than *pusillus* and *laurettae* described from the coasts of northwestern America.

As Jordan and Evermann (1911) suggest, this species, which is known only from the type localities, Point Hope and Grantley Harbour, Alaska, is probably identical with *laurettae*. The gill-raker numbers (33-37) and size of eye given by Scofield (1899) in his original description indicate its similarity to *laurettae*. Moreover he recorded *pusillus* but not *laurettae* from Grantley Harbour. In view of the fact that two and only two species of *Leucichthys* have been found in salt and brackish waters off the northern coasts of Asia and northwestern America, it seems certain that *alascanus* and *laurettae* are identical.

I have been unable to locate the type specimens, the only ones of the species ever reported.

LEUCICHTHYS LUCIDUS

The name *lucidus* has been almost entirely restricted to the lake herrings of Great Bear Lake. Only occasionally has the name been applied to other populations. For instance, Scofield (1899) identified two specimens taken in salt water off Herschel Island and Evermann and Goldsborough (1907b) specimens collected by Preble from Arctic Red River as of this species. Dymond (1936) reported that a specimen in the Provincial Museum of British Columbia had been provisionally identified as *L. lucidus*.

TABLE No. 9

PROPORTIONATE MEASUREMENTS AND COUNTS OF BODY PARTS OF *Leucichthys*
FROM GREAT BEAR LAKE, AND BAKER LAKE

	Great Bear Lake		Baker Lake†	
	12*	Range	5*	Range
Standard length	283	229-340	311	274-360
Scales	81	75- 89	80	78- 85
Gill-rakers	45.6	42- 50	43.4	40- 46
Branchiostegals	8.3	8- 9	8.8	8- 9
Head length	218	206-236	209	199-217
Head depth	147	139-158	137	125-149
Eye	48	43- 57	45	41- 49
Snout	56	51- 61	54	50- 57
Interorbital	60	56- 69	58	56- 61
Maxillary	76	69- 83	71	69- 73
Body depth	260	224-297	221	197-237
Body width	147	138-164	139	131-155
Caudal peduncle				
Length	127	113-144	129	121-140
Depth	80	76- 88	76	66- 81
Dorsal rays	11.8	11- 13	12.6	11- 14
Dorsal height	151	130-166	144	131-157
Dorsal base	107	94-119	111	105-119
Anal rays	12.3	11- 13	12.8	12- 13
Anal height	98	86-110	93	85-100
Anal base	98	85-110	105	98-111
Pectoral length	158	146-177	149	134-156
Ventral length	151	135-164	152	141-161
Adipose length	56	44- 64	63	59- 67

*Number of specimens. †Including river between Beverley and Aberdeen Lakes.

Table 9 gives proportionate measurements and numbers of scales, gill-rakers, fin rays, etc. of 12 specimens from Great Bear Lake. A study of their characters as shown by this table indicates the similarity of *lucidus* to *artedi* as suggested by Gilbert (1895).

Each species of *Leucichthys* has a characteristic combination of characters as illustrated by the difference between *pusillus* and *laurettae*. The same species will show variation in a character such as length of head, size of eye, number of scales, etc. but from one locality to another the variation is usually not so great as to obscure the similarity as shown by the same *combination* of characters.

Figure 1 has been constructed to illustrate the relations between three characters—head length, height of dorsal fin and diameter of eye of the following populations:

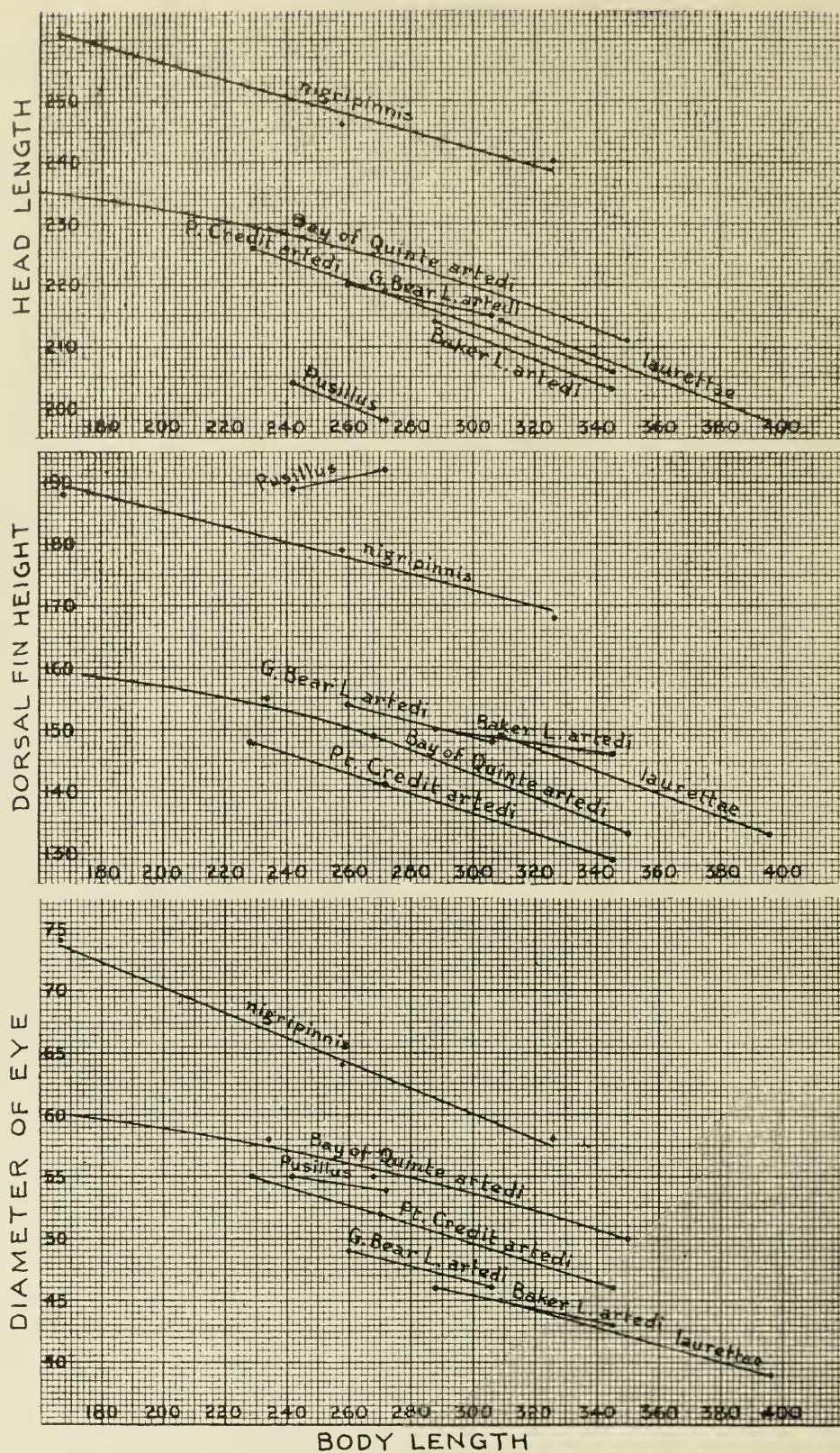


Fig. 1—Illustrating relations between head length, dorsal fin height and eye diameter of various populations of *arctedi*, and of *laurettae*, *nigripinnis* and *pusillus*.

L. artedi from two localities in Lake Ontario—Port Credit and Bay of Quinte, as found by Pritchard (1931).

L. lucidus from Great Bear Lake.

Five specimens from Baker Lake and the river between Beverley and Aberdeen Lakes.

L. laurettae

By way of contrast with the above, the same three characters of *nigripinnis* from Lake Nipigon (Dymond, 1926) and of *pusillus* are included. The values on which the curves are based are as follows:

	Number of specimens	Average length	Head length	Dorsal fin height	Eye diameter
Port Credit					
<i>artedi</i>	27	229	226	148	55
	13	272	219	141	52
	7	345	206	129	46
Bay of Quinte					
<i>artedi</i>	20	132	238	160	61
	38	234	229	155	58
	20	268	225	149	55
	4	350	211	133	50
Great Bear Lake.....	6	260	220	154	49
	6	306	215	148	46
Baker Lake.....	3	288	214	150	46
	2	345	203	146	43
<i>laurettae</i>	5	309	214	149	45
	10	396	198	133	39
<i>nigripinnis</i>	3	166	261	189	74
	7	258	246	179	64
	13	326	240	168	58
<i>pusillus</i>	6	242	204	189	55
	9	272	198	192	54

Considering the curves representing the head lengths of *artedi*, it is seen that there is considerable difference between this character in two populations within the same lake, namely the Port Credit and Bay of Quinte populations in Lake Ontario. The curve representing the head length of the Great Bear Lake *lucidus* lies between the curves for the two Lake Ontario populations. The size range and the number of specimens in the Great Bear Lake collection is not nearly as great as that of the Lake Ontario populations, which may account for the differ-

ence in the slope of the curve, although there is no reason why the change with growth should be the same in the two bodies of water.

The relatively close similarity of the head length of the Lake Ontario, Great Bear Lake, Baker Lake and *laurettae* populations in contrast to the wide divergence of the head length of these populations with that of *nigripinnis* and *pusillus* is well shown in this figure.

If we next consider dorsal height, the same situation is seen. The curves representing this character in the Lake Ontario, Great Bear Lake, Baker Lake and *laurettae* populations approximate one another much more closely than any of them do the curves representing the same character in *nigripinnis* or *pusillus*. The smallness of the size range and number of specimens represented is undoubtedly responsible for the direction of the slope of the curve representing *pusillus*. These curves illustrate graphically the fact that, as compared with *laurettae*, *pusillus* has a much smaller head but very much longer dorsal fin.

Similarly in the case of eye diameter, the Lake Ontario, Great Bear Lake, Baker Lake and *laurettae* populations show considerable similarity in contrast to the wide divergence of *nigripinnis*. In eye diameter *pusillus* is similar to the Lake Ontario *artedi*. This illustrates what has been said above that for each species there is a particular *combination* of characters. As compared with *artedi*, *pusillus* has much shorter head, very much longer fins but eye of similar size. Within the same species, eye size usually varies with head length,—an individual with large head will have a large eye in relation to standard length. In *pusillus*, the eye is similar in size to that in *artedi*, whereas the head is much shorter; in other words the eye of *pusillus* is much larger relative to head length. It will be remembered that a popular name for this species in the Mackenzie basin is "big eye".

Consideration of other characters in addition to those just considered confirms the opinion that *lucidus* is closely related to *artedi*. Pritchard (1931, p. 29) gives the average gill-raker count of Lake Ontario *artedi* as 47 and the range as 42 to 52. For *lucidus* the corresponding figures are 45.6 and 42 to 50. We have already seen that in the case of *Coregonus* gill-raker counts are lower in the northwest.

Great Bear Lake *lucidus* have more scales than Lake Ontario *artedi*, 81 average, and a range of 75 to 89 as compared with 72 and 67 to 79. It will be remembered that in considering *Coregonus*, it was found that gill-raker number was found to be more nearly constant and to show a more definite geographical trend than did number of scales.

It is therefore concluded that *lucidus* is merely a local form of *artedi*. If it is considered desirable to recognize subspecies of *artedi*, the Great

Bear Lake population will be known as *Leucichthys artedi lucidus*. As in the case of *Coregonus*, it is the opinion of the present author that, until the relation between various ecological conditions and the morphometric characters of *Leucichthys* are understood, the recognition of subspecies in this group is likely to lead to more confusion than understanding. I find myself in agreement with Hile (1936) who concluded that "the differences upon which the separation of many subspecies (of *artedi*) have been based are too slight and indefinite in comparison with the wide range of natural variation of the character used" and that "pending the accumulation of adequate data for the separation of *artedi* forms according to their true and natural relationships, it would appear that the designation of a local form can be made best through a description of its salient characters and a recording of the locality it inhabits".

BAKER LAKE *LEUCICHTHYS*

The above discussion has included a comparison of the characters of *Leucichthys* from Baker Lake and vicinity with those of Lake Ontario and Hudson Bay *artedi*. This comparison has brought out the similarity between these three populations in the matter of head length, dorsal fin height and eye diameter. The small number of specimens may be responsible for the differences in gill-raker and scale counts between the Great Bear Lake and Baker Lake populations, although as we have seen in the case of *Coregonus*, such small differences between neighbouring bodies of water are to be expected. Pritchard (l. c.) found a considerable difference in number of scales in Lake Ontario *artedi* of different sizes. Whether this is due to difference between different year classes or is related to some other character has never been determined.

The present collection of Baker Lake *Leucichthys* may therefore be regarded as belonging to the species *artedi*.

RELATIONSHIP OF *LAURETTAE* TO *ARTEDI*

The resemblance of *laurettae* to *artedi* has been noted by Bean (1882b; 1884; 1890; 1894) and to *lucidus* by Evermann and Smith (1896) and Jordan and Evermann (1896; 1911).

Figure 1 illustrates the similarity in head length, dorsal fin height and eye diameter between *laurettae* and various populations of *artedi*. *laurettae* however has a considerably lower gill-raker count than Great Lakes *artedi* or Great Bear Lake *lucidus*, here regarded as a form of *artedi*. The average and range in gill-maker numbers of these forms is as follows:

		<i>Gill-rakers</i>	
	<i>Authority</i>	<i>Average</i>	<i>Range</i>
Lake Ontario <i>artedi</i>	Pritchard (1931)	47	42-52
“ “ <i>artedi artedi</i>	Koelz (1929)	47.9*	41-54
“ “ <i>artedi albus</i>	“	47 *	
Lake Erie <i>artedi artedi</i>	“	47.3*	44-51
“ “ <i>artedi albus</i>	“	46.3*	41-53
Lake Huron <i>artedi artedi</i>	“	47.1*	40-53
“ “ <i>artedi manitoulinus</i>	“	45.9*	43-50
Lake Superior <i>artedi</i>	“	47 *	38-53
Lake Nipigon <i>artedi</i>	“	47.5*	41-53
“ “ <i>artedi</i>	Dymond (1926)	46	41-57
Great Bear Lake <i>lucidus</i>		45.6	42-50
Hudson Bay <i>artedi</i>	Dymond (1933)	43	40-46
<i>laurettae</i>		42	38-47

*Average from Koelz's tables 67-78.

It is thus seen that while *laurettae* diverges considerably in gill-raker number from Great Lakes *artedi* and Great Bear Lake *lucidus*, the divergence between it and Hudson Bay *artedi* is not nearly as great. Whether the salt water habitat has something to do with the low gill-raker count is not known; there is not the same correspondence between the number of gill-rakers of Hudson Bay and Kittigasuit *Coregonus*.

As has already been pointed out, the premaxillaries of *laurettae* are usually nearly vertical, whereas in typical *artedi* they are at a wide angle to the vertical. Because of this character and the divergence in number of gill-rakers as well as on distributional grounds, the *Leucichthys* which have been designated as *laurettae* should continue to be regarded as distinct from *artedi* although it is admitted that it may be impossible to distinguish occasional specimens. In any case, *artedi* is close to the *laurettae* which is here considered synonymous with the Asiatic *autumnalis*.

LEUCICHTHYS ARTEDI IN NORTHWESTERN CANADA AND THE RELATION THERETO OF *L. TULLIBEE*

L. artedi is the most widely distributed of all the species of *Leucichthys*, both ecologically and geographically.

The lake herrings living in the streams tributary to Hudson and James Bays and resorting to salt or brackish waters at certain seasons have been identified as belonging to this species (Bean 1882a, Dymond 1933). Typical *artedi* have been identified in a collection made by Dr. D. S. Rawson in Reindeer Lake, northern Saskatchewan, and the preceding discussion has shown that the same species occurs in waters farther north and west (Baker Lake and river between Beverley and Aberdeen Lakes and also in Great Bear Lake). Undoubtedly the species is found in all suitable waters in intervening and surrounding areas.

The name *tullibee* was given by Richardson (1836) to a form of *Leucichthys* which he said was "very generally diffused through the waters of the fur countries". His description was based on specimens from Cumberland House on Pine Island Lake in northern Saskatchewan. Redescription of specimens from this locality has been given by Dymond (1928). If the lengths of the heads and eyes of the specimens whose measurements are given in this account are plotted on figure 1 it will be found that they approximate much more closely to the values for *nigripinnis* than to those of *artedi*. Moreover there occurs in western lakes south of the Precambrian shield a *Leucichthys* which possesses many of the features of *nigripinnis*. Specimens available for study are too few to enable a decision to be reached as to the status of this form or as to the possible relationship of *tullibee* to *artedi* or *nigripinnis*. Koelz's (1931) assumption that *tullibee* is a subspecies of *artedi* may be unwarranted. The same applies to his description as subspecies *magnus* (of *artedi*) of a *tullibee*-like form from Lesser Slave Lake and as subspecies *winnipegosis* of closely related forms from Lake Winnipegosis in Manitoba and from a number of lakes in northwestern Ontario. In any case, there is serious doubt as to the wisdom of recognizing subspecies among coregonine fishes at the present time.

LEUCICHTHYS ZENITHICUS

The species identified as *zenithicus* and recorded as such from Lake Winnipeg and Lake Athabasca by Dymond and Pritchard (1930) is now regarded as extending into the Northwest Territories.

I have been privileged to examine a collection of 13 specimens which I identify as *zenithicus* taken by Dr. D. S. Rawson of the University of Saskatchewan in Reindeer Lake, northern Saskatchewan, during the summer of 1942. Three of these specimens were taken from the stomachs of *Cristivomer*. Study of these various collections has convinced me that the specimens regarded as the types of the species *macrognathus*, *athabasca* and *entomophagus* by Harper and Nichols (1919) may all be identified as *zenithicus*.

Koelz (1929) characterizes *zenithicus* as "elongate, subterete fishes of relatively moderate size, with short, usually included mandible, relatively long snout and maxillary, shallow head and a moderate number of gill-rakers and lateral line scales". Referring to the characteristically long maxillary, Jordan and Evermann (1911) and Dymond (1926) call *zenithicus*, the longjaw.

Table 10 presents proportionate measurements of specimens from a number of localities, including measurements made by the author on the type specimens of *Leucichthys macrognathus*, *L. athabasca* and *L. entomophagus*, preserved in the National Museum of Canada.

TABLE No. 10

PROPORTIONATE MEASUREMENTS OF *Leucichthys zenithicus* FROM LOCALITIES
IN NORTHWESTERN CANADA

- A. Average for 6 specimens from Lake Nipigon, from Dymond (1926).
- B. Average for 6 from Lake Winnipeg.
- C. Average for 7 from Lake Winnipeg.
- D. Average for 2 from Reindeer Lake, Sask.
- E. Average for 4 from Reindeer Lake.
- F. Average for 4 from Reindeer Lake.
- G. Type of *L. macrognathus*.
- H. Type of *L. athabasca*.
- K. Type of *L. entomophagus*.

The measurements for G., H., and K. were made by the author on type specimens in the National Museum of Canada.

	A	B	C	D	E	F	G	H	K
Standard length.....	272	261	231	264	165	144	201	137	134
Scales.....	70	65	64	74	76	66	65	65	...
Gill-rakers.....	37	38	38	37	36	34	37	35*	35
Head length.....	246	237	249	242	246	256	239	241	239
Head depth.....		156	166	160	160	163	149	146	157
Eye.....	57	62	65	59	68	72	57	66	71
Snout.....	70	57	63	63	65	67	62	58	63
Interorbital.....	54	60	62	68	63	65	50	55	63
Maxillary.....	96	86	93	94	96	98	90	91	90
Body depth.....	243	281	298	246	225	218	219	182	239
Body width.....	112	146	149	137	114	120	109	80	112
Caudal peduncle									
Length.....	127	121	117	123	131	125	129	117	101
Depth.....	73	93	96	80	78	77	67	73	83
Dorsal height.....	173	192	202	157	161	160	195	153	157
Dorsal base.....	117	117	117	114	112	104	114	106	131
Anal height.....	110	131	121	100	101	99	122	...	97
Anal base.....	105	117	121	102	105	105	107	102	123
Pectoral length.....	169	178	199	159	158	159	216	161	164
Ventral length.....	163	163	200	158	156	158	179	164	160

*As stated by Harper and Nichols.

This table emphasizes a fact already noted in connection with several species, namely that gill-raker number is the most stable of the characters generally used to distinguish species of coregonine fishes. The average number of gill-rakers of 20 *zenithicus* from Lake Superior listed by Koelz (1929, table 25) is 39.4 and for Lake Nipigon, 37.6. The total range of gill-raker number for Great Lakes *zenithicus* given by Koelz is 32 to 46. The range found for the 23 specimens from Lake Winnipeg and Reindeer Lake was 29 to 40. The specimen which had 29 on the left arch had 35 on the right. Apart from this abnormal specimen, 33 was the lowest gill-raker count found. The numbers of gill-rakers possessed by the specimens described by Harper and Nichols under the names *macrognathus*, *athabasca* and *entomophagus* correspond to those characteristic of *zenithicus*.

Number of scales in the lateral line shows a greater variation geographically than does number of gill-rakers. Twenty Lake Superior specimens listed by Koelz (table 25) had an average of 78 scales, with a range of 69 to 90 for 956 specimens. Twenty from Lake Nipigon listed by the same author had 73.5 scales. While the specimens designated as *macrognathus* and *athabasca* have fewer scales than most collections of *zenithicus*, the numbers are well within the range for *zenithicus* and are the same as those of collections B and C. A low number of scales is a characteristic feature of *zenithicus*.

A long maxillary is another characteristic *zenithicus* feature. In this character also, *macrognathus*, *athabasca* and *entomophagus* agree with *zenithicus*.

Body depth appears to be one of the most variable of body proportions in *zenithicus*. Koelz (1929) noted that "those small fish that have been taken from depths of more than 60 fathoms appear to have, on the average, a slightly shorter snout and greater body depth" and "rather marked variations are exhibited by the small specimens". The type of *L. athabasca* differs markedly from normal *zenithicus* in body depth and width, but its other characters place it definitely in that species.

Fin length is another character in which there is marked difference between populations of *zenithicus* from different localities. Lake Winnipeg specimens (B and C, table 10) have considerably longer fins than Lake Nipigon (A) or Reindeer Lake (D, E, F) specimens. Similarly the type of *macrognathus* has longer fins than the types of *athabasca* and *entomophagus*.

Considering the combination of characters possessed by *macrognathus*, *athabasca* and *entomophagus*, there can be no doubt that they belong to the species here designated as *zenithicus*.

The type of *macrognathus* came from Great Slave Lake, of *athabasca*

from Lake Athabaska, and of *entomophagus* from Tazin River. *L. zenithicus* has already been reported from Lake Athabaska (Dymond and Pritchard, 1930).

LEUCICHTHYS NIGRIPINNIS

Leucichthys nigripinnis has not yet been recognized from the waters of the Northwest Territories proper. Dymond and Pritchard (1930) recorded it from Lake Winnipeg, Manitoba; Waskesiu, Little Trout, Burntwood and Heart Lakes in Prince Albert National Park, Saskatchewan, and from Lake Athabaska, Alberta, and recently the present author recognized the species in a collection made by Dr. D. S. Rawson in Reindeer Lake, northern Saskatchewan.

STENODUS

In America *Stenodus* is confined to Alaska, Yukon and Northwest Territories. The genus also occurs in the Arctic drainage of Asia as far west as the White Sea; an isolated colony is found in the Caspian sea. See map in Dymond and Vladykov (1934). Berg (1932) regards the Asiatic and American populations as constituting a single species, *Stenodus leucichthys*. The form occupying the Arctic drainage of Asia is regarded as subspecies *nelma*, that is, *Stenodus leucichthys nelma*.

Richardson (1823) gave the form found in the Mackenzie basin the specific name *mackenzii* and this name has been generally applied to it since that time.

The fish was early given the common name *inconnu* by the French Canadian voyageurs. On the Yukon it is said to be called *acouda*, perhaps a corruption of *inconnu*. Hearne's (1795) account of the taking of a specimen in Great Slave Lake in 1772 is perhaps the earliest published reference to this fish in Canada. He does not mention it by name but his description can hardly refer to any other species. Mackenzie (1801) speaks of catching in his nets in Great Slave Lake on June 9, 1789, "Carp (suckers), *poisson inconnu*, whitefish and trout". Also "on July 13th at the mouth of the Mackenzie the nets yielded seven *poisson inconnus* which were unpalatable".

DESCRIPTION

Proportionate measurements of 13 individual specimens are given in table 11. A description based on the measurements of 11 specimens over 60 cm. in standard length, all from Slave River (Great Slave Lake population), is as follows. The measurements are in percentage of the standard length.

Head length, 26.7 (25.9-27.7); head depth 15.3 (14.5-15.7); eye, 3.5 (3.2-3.8); snout 6.0 (5.7-6.5); interorbital 4.8 (4.4-5.2); maxillary 9.4

[illegible]

The lower jaw is longer than upper and usually somewhat hooked; supplementary maxillary as wide as the maxillary; bristle-like teeth on palatines, vomer, tongue, premaxillary and head of maxillaries, much weaker ones anteriorly on lower jaw; nostrils with two flaps as in *Coregonus*. Caudal fin edged with darker, dorsal dusky at tip; other fins immaculate.

It will be noticed that the 2 females are larger than any of the males. The measurements suggest that males have deeper and wider bodies than females.

The identity of *S. mackenzii* of the Mackenzie and Yukon Rivers and *S. leucichthys nelma* of Siberian rivers has often been suggested (Scofield 1899, Halkett 1913, Melville 1914, Berg 1932).

Berg gives the scale and gill-raker counts of *nelma* as 88-118 and 18 (19-23) respectively. The former is a wider range than found in the specimens of Mackenzie River fish available for study but the gill-raker count is similar in the two areas. Berg is probably correct in regarding the American species as conspecific with the Asiatic. In that case, ours should be known as *Stenodus leucichthys mackenzii* if subspecies are recognized.

DISTRIBUTION

Melville (1914) gives the general distribution of the inconnu as follows: "... inhabiting, as far as the first rapids, most of the large rivers and streams of Alaska and Arctic Canada from the Yukon to the Anderson river." The Anderson appears to be the most easterly of the rivers occupied by the inconnu. So common is the species in this river that it is said to be called Connie River. Anderson (1913) said that he had never seen an inconnu east of Cape Bathurst.

From available information it appears that the inconnu in the Mackenzie basin is largely confined to Great Slave Lake and the lower Mackenzie as far south as the ramparts. The only record for Great Bear Lake is that of Simpson (1843) who reported one caught in a white-fish net near Fort Confidence at the eastern extremity of the lake. The United States National Museum has a specimen from Fort Simpson, where specimens are taken in the fall.

From Great Slave Lake they ascend at spawning time many of the tributary streams including Slave River as far as the rapids at Fort Smith. Melville (l.c.) said that they ascend most of the rivers flowing into the lake from the north but the Riviere de Rochers (now Taltson River), Stony Island, Buffalo and Slave Rivers were said to be those visited in largest numbers. Sergeant Mellow, R.N.W.M.P., is quoted as saying "that he was nearly able to walk across the Buffalo River on

their backs". This statement apparently refers to the Big Buffalo River; Chambers (1914) quotes Mellor as describing the ascent of the Big Buffalo River as follows, "The river was literally alive with 'coney's' It was quite unnecessary to use a net or line to catch them as it was a simple matter to throw them on land with a paddle or stick".

Frank Conibear reports having taken inconnu in the Taltson River. He reports heavy runs on the Big Buffalo River but doubts if they are as abundant in the Little Buffalo or in the Hay. Preble (1908) took it at the lowermost rapid on the Grandin River. Mr. Alf Reeve of Toronto has caught an inconnu at the mouth of the Yellowknife River on a troll.

So far as movement of inconnu in the lower Mackenzie is concerned Melville said they did not ascend beyond Swift River above Fort Good Hope. They were said to be less abundant in the lower Mackenzie than in Slave River although some are taken in gill nets every summer at all the trading posts. Tributaries of the lower Mackenzie in which the inconnu are known to be found include the Peel, Rat and Arctic Red Rivers. West of the mouth of the Mackenzie, the inconnu is not known beyond Herschel Island (Anderson, 1913).

Evermann and Goldsborough (1907a) recorded the inconnu from the headwaters of the Yukon and our collection contains a specimen from that river. Bean (1894) gives its distribution in Alaska as "from the Kuskoquim to the Kuwuk".

LIFE HISTORY, FOOD VALUE, ETC.

In the lower Mackenzie the inconnu is regarded as anadromous, wintering about the delta and entering the Mackenzie and some of its tributaries for spawning. The movements however have never been critically observed. Berg (1932) describes the Siberian *Stenodus* which is popularly called *nelma*, as a semi-migratory fish which begins to enter the rivers after they are free of ice.

Mr. K. H. Lang describes the inconnu as abundant in the delta region of the Mackenzie. It seems to prefer the larger channels to the smaller ones. It is said to be most abundant in the shallow water over the large mud flats on both sides of Richards Island and of other islands to the west. It goes out into quite brackish water. Mr. Lang reported that three men in 21 days caught 9,000 inconnu at Kidluit during the fall of 1935. The water there is quite brackish. The inconnu caught at that point in the fall (September) are mostly young fish. They come in from the open, brackish flats, and appear to be on their way to the Mackenzie. On their inward migration they follow the shores of the island quite closely.

Anderson (1913) says inconnys are "found in brackish and salt water . . . occasionally as far west as Herschel Island Large numbers are caught in gill-nets in brackish water at Shingle Point, Mackenzie Bay in July and August, but the flesh is rather soft and flabby at that season. Eskimo catch many with barbless hooks through the ice on the east mainland side of Richards Island in October, November and December. The connies are fat and firm of flesh at that season".

The fact that most of the inconnu caught in the fall among the islands are young fish suggests that perhaps the larger individuals move into the Mackenzie earlier than the smaller ones. Considerable numbers are said to enter the Peel and Rat Rivers in July and August. Mr. H. V. Dempsey states that in the Peel River, from its junction with the Mackenzie up to Fort McPherson, he has seen young inconnus twelve to eighteen inches in length caught in great numbers during the month of August. In August 1934, he saw at Fort McPherson 527 young inconnus caught in two hundred yards of five-inch-mesh gill-net set for only two hours, from 6 to 8 a.m. According to Berg (1932) "from the delta of the Kolyma the nelma runs up throughout the whole of June, while in July it is rarely found in the delta; in August and September only sexually immature nelma are found". One reason for fall fishing among the islands appears to be that at this time the weather, in the words of Mr. Lang "is cold enough for the fish to be thrown right into the scow and later transported up the river to Aklavik; although smelling to high heaven, they make excellent dog feed for the winter".

From Great Slave Lake the inconnu enters the tributary streams on their spawning migrations from the end of July until the freeze-up. Mr. Frank Conibear, who secured 12 specimens for the Royal Ontario Museum of Zoology at Fort Smith in September, 1933, says that on the Slave River the catch is at its height about the first part of September. Some indication of their numbers is given by the statement that a man could catch from 5 or 6 to 20 a day at the height of the run. With reference to their occurrence in other streams he wrote: "In September, 1914, went to the mouth of the Taltson River; practically all the fish caught there were coney. Just at the entrance the river opens out in a small shallow lake about a mile wide; in the middle of the lake there is a bar about 2 or 3 feet deep. Each day I passed here twice and always ran into a shoal of coney apparently sleeping. At the end of September, 1916, I went back to the same place, but did not do so well, so went up to the first rapids on the Taltson about 25 miles; here the fishing was good. We set one three pound bundle of nets, and overnight caught, if my memory is correct, 150 coney, and a number of other fish. We had

to make two trips with the boat, and in the evening there were almost as many. The Indians were catching all they wanted; there seemed to be no limit."

After spawning, the inconnu is believed to return to Great Slave Lake and to the delta region at the mouth of the Mackenzie. Preble (1908) quotes Père Giroux as saying that the inconnu pass Arctic Red River from about the second week in June to the first of August, and reach there on their return toward the end of October, and that they winter at the mouth of the Mackenzie, and also that they "ascend the Mackenzie in summer but apparently do not winter in that stream." We have already recorded their capture there in winter by the Eskimos. They are said to be incapable of surmounting rapids, although they will pass through quite swift water.

The inconnu is of considerable value as a food fish. Mr. Lang, who has spent many years in the Aklavik area, says: "It is a beautiful fish and in very much favour as human food, and also as dogfood, although the smaller connies are a little dry and lean; but the bigger they are, the fatter they get, and a piece of the tail of a big connie is generally considered the best feed of fish obtainable in the country". The palatability of the inconnu appears to be a matter of taste. Richardson (1836) wrote: "Its flesh is white, and when in good condition, tolerably palatable, though rather soft and oily, and soon becoming disagreeable when used as daily food; it is firmest and best near the mouth of the Mackenzie, and when out of season is considered by the natives to be very unwholesome". They are usually preserved for use by being dried or smoked. The fish are generally split and hung on a stage out of reach of the dogs.

The largest inconnu of which I have record weighed just over 63 pounds. This fish was taken by Mr. K. H. Lang at his Camp 3 (see map) on July 12, 1936. It was $59\frac{1}{4}$ inches in length. Mr. Lang described it as "rolling fat. I took 6 lbs. of fat from the entrails, then I had a big dinner and fed 17 sleigh dogs out of it besides". The largest inconnu seen by Mr. Harry V. Dempsey, of the Fisheries Service, Alberta Department of Agriculture, in several years fur-trading at Fort McPherson, Aklavik and Tuktoyaktok (Port Brabant) weighed $56\frac{1}{2}$ pounds. Mr. Lang reports that he has seen several inconnu between 45 and 55 pounds in weight; 25 to 30 pound fish are quite common, while the average run is from 6 to 12 pounds. It is said to be less common and not to reach as large a size on the Yukon. Hon. George Black informed me that they occur at Dawson City up to 14 pounds in weight.

The stomachs of six of the specimens in the present collection contained food. In every case this consisted of fish or fish remains, as indicated below:

<i>Museum number</i>	<i>Length in cm.</i>	<i>Stomach contents</i>
5190	63.5	Remains of <i>Esox lucius</i> 6" and 7" long respectively.
5137	64.0	3 <i>Pungitius pungitius</i> , each 1" long; remains of one other fish 1½" long.
5191	66.0	1 <i>Esox lucius</i> 7".
5195	67.5	1 <i>Esox lucius</i> 7¼", remains of one other fish.
5193	68.0	1 <i>Amphiodon alosoides</i> 5¼".
5185	68.8	1 <i>Amphiodon alosoides</i> 5¾", 1 <i>Esox lucius</i> 6", remains of one other fish 6".

The above specimens were all taken at Fort Smith, 5137 on Aug. 28, and the others in September. Speaking of the food of the inconnu of the lower Mackenzie, Mr. Lang says "For the summer, the stomach of most connies caught contains vegetable matter, only a few have small fish in them, but at Camp 1 this fall in October, I have examined 20 connies and they all contained nothing but fish. I give the stomach contents of an 8 lb. connie as a fair average example: 10 small ling (*Lota*) and jackfish (*Esox lucius*) about 2 to 3 inches long, and about 300 sticklebacks."

As has already been said, the inconnu, at least at certain seasons, will take a bait or lure. The Eskimos in the delta region catch them through the ice on barbless hooks (Anderson), by means of a spoon or bait, such as a piece of meat or fish, or on a hook baited with a thin strip of bone or ivory (Melville) or by line and hook without barbs, baited with whitefish gut or sometimes just a piece of white bone (Lang). Hon. George Black reports that on the Yukon at some seasons of the year they furnish good sport with a troll or minnow. He describes them as hard fighters. This is in contrast to the condition on the Mackenzie where it is described as "a fish of no great vitality, it being generally found dead in the nets, as compared to the whitefish or trout which caught at the same cast are still full of life" (Melville). Lang says "the real big connie never fight the net".

Efforts to determine the ages of the specimens in the present collection were not very successful, owing to the difficulty of reading the scales. The scales of the two largest specimens, both females, were illegible. The others, all males, 26 to 29 inches long to fork of tail; 608 to 687 mm. in standard length), appeared to be 8 to 10 years old. These were all taken at Fort Smith and hence were of the Great Slave Lake population. However, a specimen 690 mm. in standard length taken at Fort McPherson appeared to be of the same age so that the present collection gives no evidence of a difference in growth rate between the Great Slave Lake and lower Mackenzie populations.

Attention has already been drawn to the fact that the 2 females in the collection from Great Slave Lake were larger than any of the males. Berg (1932) in discussing the Caspian Sea form gives the weight and length of sexually mature females as 18.6 kg. and 90-95 cm. respectively and the corresponding figures for mature males as 16.0 and 80-90. Berg also reports that Kolyma males reach sexual maturity at 11-12 years of age, females ordinarily from 14 years. Males above 16 years of age are not found, while females are found at 20+ years of age. The same author gives the length (to the end of the middle rays of the caudal) of Pechora River *nelma* of various ages as follows:

At end of	4th	winter		300 mm.
"	"	6th	"	436 mm.
"	"	8th	"	573 mm.
"	"	10th	"	675 mm.
"	"	12th	"	776 mm.
"	"	14th	"	846 mm.
"	"	16th	"	904 mm.

POSSIBILITY OF RACIAL DIFFERENCES IN AMERICAN *STENODUS*

Asiatic populations of *Stenodus* consist of a freshwater form *Stenodus leucichthys leucichthys* in the Caspian Sea and a migratory form *Stenodus leucichthys nelma* in the rivers of Siberia as far west as the White Sea. As already suggested, the *Stenodus* of the Mackenzie basin appears to consist of a "land-locked" or freshwater form of Great Slave Lake and a migratory form of the lower Mackenzie.

Although the inconnu is reported from all of the posts along the Mackenzie including Norman, Wrigley and Simpson, they appear to be much commoner below Norman. They are practically unknown in Great Bear Lake. Preble (1908) says the inconnu "remains in Great Slave Lake the year round, but as far as I know this is the only inland lake which is thus distinguished."

Berg (1932) distinguishes the two Asiatic subspecies as follows:

- a. Gill-rakers on the first arch 18 (19-23) 24. The basin of the Arctic Ocean.....*Stenodus leucichthys nelma*
- aa. Gill-rakers on the first arch 19-25, average 22-23. The basin of the Caspian Sea.....*Stenodus leucichthys*

In his descriptions he gives the scales of *leucichthys nelma* as 88-118 and of *leucichthys* as 99-120, average 109.3.

The collection on which the present work is based was not large enough to give any clear indication as to whether the Great Slave Lake and lower Mackenzie populations have diverged morphologically.

Eleven of the specimens whose measurements and counts are given in table 11 were from the Slave River. The number of scales (to end of vertebral column) of these eleven specimens averages 103, with a range of 100 to 107.

The following specimens from the lower Mackenzie had the number of scales and gill-rakers indicated.

<i>Specimen number</i>	<i>Origin</i>	<i>Number of scales</i>	<i>Gill-rakers</i>
13443	Fort McPherson.....	98	22
13444	" ".....	103	20
5642	Arctic Red River.....	97	19

The average number of scales of these three is 99.3. The specimen from the Delta of Mackenzie recorded by Gilbert (1895) had 100 scales and 24 gill-rakers. Scofield (1899) gave the scales and gill-rakers of 3 specimens from the mouth of the Mackenzie as 103 and 22 respectively. It is not known whether the scales indicated by Gilbert and Scofield were to the end of the vertebral column as in the case of specimens examined in connection with the present work or to the end of the lateral line. If the latter is the case, they support the view suggested by the present collection, namely that the Great Slave Lake specimens have more scales than those from the lower Mackenzie. The one Yukon River specimen (5682) included in table 11 also had a reduced number of scales. Berg's description of the Asiatic forms also suggest a higher number of scales in the Caspian or freshwater form.

STENODUS X LEUCICHTHYS HYBRIDS?

Four specimens tentatively identified as hybrids are included in the collections from northwestern Canada. These are all skins. Details of their characters are included in table 12. The proportionate measurements cannot be as accurate as those of whole specimens but are believed to be sufficiently accurate for purposes of comparison with the parent species. Such measurements as standard length, depth, etc. have been carefully estimated for the purpose of constructing this table.

Hybrids between the Siberian *Stenodus leucichthys nelma* and two Siberian species, *Leucichthys autumnalis* and *Coregonus muksun* have been reported by Kuznetsov (1932).

The number of gill-rakers reported by Kuznetsov for the *Stenodus x autumnalis* hybrid is similar to that in the present specimens, namely 34. This he says is intermediate between the number in *Stenodus* (18-21) and in *autumnalis* (39-51).

In the four specimens here described, the lower jaw is included and

TABLE No. 12

PROPORTIONATE MEASUREMENTS OF PRESUMED HYBRIDS *Stenodus* X *Leucichthys*,
TAKEN 6 MILES NORTH OF KIDLUIT, SEPTEMBER, 1938

Number.....	10927	10924	10928	10926
Standard length.....	512	480	440	420
Scales.....	85	85	80	80?
Gill-rakers.....	34	34	34	32
Branchiostegals.....	9	8	8	8
Pyloric caeca.....	223			134
Head length.....	193	199	195	210
Head depth.....	136	144	142	144
Eye.....	35	37	39	40
Snout.....	51	52	51	52
Interorbital.....	65	63	63	64
Maxillary.....	61	59	63	60
Body depth.....	205	171?	255	205
Body width.....				
Caudal peduncle				
Length.....	96	113	108	87
Depth.....	87	90	86	90
Dorsal rays.....	14	13	13	14
Dorsal height.....	144	146	148	150
Dorsal base.....	133	113	114	117
Anal rays.....	13	14	14	13
Anal height.....	109	102	75	104
Anal base.....	117	111	114	110
Pectoral length.....	147	154	173	157
Ventral length.....	143	139	148	140
Adipose length.....	83	77	82	69

the premaxillaries vertical. Kuznetsov's *Stenodus* x *autumnalis* hybrids had the upper jaw shorter than the lower as in *Stenodus*. If *L. laurettae* is the American form of *autumnalis* as suggested above, the specimens here considered are probably hybrids between *Stenodus* and *L. laurettae*. This is the interpretation placed on them by Mr. Lang, who secured them for us. He wrote: "Before I leave the connie (*Stenodus*) I will mention some fish caught at Camp 9 at Okivik three years ago. They had the appearance of herring but the size of a fair connie about 9-11 lbs. They decidedly were no herring and they lacked the long heavy lower jaw of the connie. I showed them to an old Eskimo and he said 'him halfbreed' and it certainly appeared to be just that. I caught about 6 or 7 both years I was there. This year I caught at Camp 8 a fish of such an appearance that I would call it a cross between a connie and a whitefish". They are not common according to Mr. Lang. The Eskimos have a name for the hybrid, Ekaluitnak. *Stenodus* they call Segak.

In the Lena River area of Siberia, Kuznetsov says "These hybrids

present no exclusive rarity, for among the local population they are known under the special name of 'Andy-balyk' (Yakutian) or 'whitefish' (Russian) by which they distinguished from the 'nelma', 'omul' and 'muksun'."

SUMMARY

The species of coregonine fishes occurring in the Yukon and Northwest Territories of Canada are *Coregonus clupeaformis* (Mitchill), *Prosopium cylindraceum* (Pallas), *Leucichthys autumnalis* (Pallas), *Leucichthys sardinella* (Valenciennes), *Leucichthys artedi* (Le Sueur), *Leucichthys zenithicus* (Jordan and Evermann), *Stenodus leucichthys* (Güldenstadt).

Proportionate measurements of body parts and counts of gill-rakers, scales, fin rays, branchiostegals and in many cases, pyloric caeca based on original measurements are presented for all of the above species.

The following species are reduced to synonymy:—*Coregonus nelsonii* Bean, *C. kennicotti* Bean, *C. odonoghuei* Bajkov, *C. atikameg* Bajkov as synonyms of *C. clupeaformis*. Bajkov's record of *C. nasus* in Canada is also placed in the synonymy of *C. clupeaformis*. *Prosopium quadrilaterale* (Richardson) and *P. preblei* (Harper and Nichols) are synonymous with *P. cylindraceum*. Two species of *Leucichthys*, *pusillus* (Bean) and *laurettae* (Bean) found in and about the mouths of the rivers of Alaska and the Northwest Territories flowing into Bering sea and the Arctic Ocean are regarded as synonymous with *L. sardinella* and *L. autumnalis* of Siberia.

Leucichthys lucidus (Richardson) is synonymous with *L. artedi* and *L. entomophagus* (Harper and Nichols), *L. athabasca* (Harper and Nichols) and *L. macrognathus* (Harper and Nichols) with *L. zenithicus*. *Stenodus mackenzii* (Richardson) is synonymous with *S. leucichthys*.

Prosopium oregonium is recorded from Lesser Slave Lake, Alberta.

The *Coregonus* populations of a number of waters in the Yukon and the Northwest Territories are compared with Great Lakes *Coregonus* and it is shown that while the populations of different waters differ in body proportions and in such characters as number of gill-rakers, scales, etc., most of these characters show ecological rather than geographical variation. It is therefore concluded that until some relationship has been worked out between environmental factors and body characters of *Coregonus*, the recognition of subspecies on the basis of the characters of individual local populations adds to confusion rather than to enlightenment.

The same conclusion holds for all species of coregonines in the present state of our knowledge.

Number of gill-rakers is the most stable of the characters generally used to distinguish species of coregonines.

Number of pyloric caeca is one of the most variable of the characters studied.

Number of gill-rakers in *Coregonus* is the only character in which an approach to a geographical cline was found.

In the extreme northwest of Canada the typical number of gill-rakers in *Coregonus* is 22-23, in intermediate waters 25-26, in Hudson Bay, 26-27 and in the Great Lakes 27-28. However in Squanga Lake, Yukon Territory the number is 28.

Length of fins in *Coregonus* appears to show a definite correlation with ecological conditions in that collections from rivers had longer fins than collections from lakes.

The *Stenodus* of the Mackenzie River valley appears to consist of two populations,—a freshwater one in Great Slave Lake and an anadromous one in the lower Mackenzie. Some indication of differences in number of scales in the two populations was found.

Specimens regarded as hybrids between *Stenodus* and *L. autumnalis* are recorded from waters about the Mackenzie delta.

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